SURVEY OF MOSQUITOES OF MASSACHUSETTS

REPORT

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SURVEY OF MOSQUITOES OF MASSACHUSETTS

FINAL REPORT
1940

MASSACHUSETTS DEPARTMENT OF PUBLIC HEALTH
IN COOPERATION WITH THE
WORK PROJECTS ADMINISTRATION

COMMONWEALTH OF MASSACHUSETTS

DEPARTMENT OF PUBLIC HEALTH

PAUL J. JAKMAUH, M.D., COMMISSIONER

AND

FEDERAL WORKS AGENCY

WORK PROJECTS ADMINISTRATION

DENIS W DELANEY ADMINISTRATOR

A SURVEY OF THE MOSQUITOES OF MASSACHUSETTS

WITH

A DISCUSSION OF THE RELATION OF MOSQUITOES TO DISEASE

COMPILED BY

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UNDER THE DIRECTION OF

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DIRECTOR, DIVISION OF COMMUNICABLE DISEASES

1940

WILLIAM A. HOGAN, PROJECT SUPERVISOR

PREFACE

Paul J. Jakmauh, M.D.
Commissioner of Public Health

This edition of an abbreviated report is being made available for limited distribution to those interested in the outstanding results of the mosquito survey carried out in Massachusetts in the summer of 1939.

In evaluating the figures given in the report, it must be constantly kept in mind that they are largely qualitative and not quantitative. They represent not so much an indication of the comparative number of mosquitoes found in the various communities but are rather a measure of the diligence of the collectors and the cooperation of the boards of health and other local organizations. As a result the communities which gave greater assistance in supplementing the collections made by the W.P.A. personnel would appear at first glance to have a greater variety and abundance of mosquitoes than those in which the collections were made only by the regular collectors.

The number of individuals and organizations who aided in this survey are too numerous to refer to in this preface, but references to them will be found in various portions of the report itself. Suffice it to say that the success of the project depended upon the cooperation of all those concerned and the splendid results obtained are evidence of that cooperation.

This survey has collected more information concerning mosquitoes than is available in regard to any other comparable area in the country. The facts obtained will make more intelligent planning of control measures possible in the future, whether to eliminate mosquitoes as a pest or to guard the population against the spread of disease.

INTRODUCTION

As a result of the outbreak of equine encephalomyelitis in 1938, the Massachusetts Department of Public Health decided that plans should be made to prevent the disease in the future. A committee called together by Dr. Paul J. Jakmauh, Commissioner of Public Health, considered the problem in detail and decided that the most pressing need was complete information in regard to the most probable vector, the mosquito. At the urgent request of the Commissioner, Governor Leverett Saltonstall presented the following message to the General Court of Massachusetts:

HOUSE . . . . NO. 2181

The Commonwealth of Massachusetts

Executive Department,
State House, Boston, April 12, 1939.

To the Honorable Senate and House of Representatives:

House Bill No. 399, A resolve providing for an investigation by the Department of Public Health, in co-operation with the Federal Works Progress Administration, relative to the varieties and prevalence of certain kinds of mosquitoes in the Commonwealth of Massachusetts, calls for an appropriation in the aggregate of $17,500. This sum will be the Commonwealth's contribution to the cost of the investigation and will permit the Department of Public Health to investigate in co-operation with the Federal Works Progress Administration, the prevalence and the seasonal and geographical distribution of mosquitoes throughout the Commonwealth.

Last summer there was an epidemic of encephalomyelitis in certain parts of our Commonwealth. This is an extremely dangerous disease to young people and there is considerable fear among the authorities that there may be a recurrence of this epidemic in the coming summer months. Work with relation to mosquitoes, to be effective, must be done in the month of May.

I, therefore, recommend this appropriation to be made in advance of the budget.

Leverett Saltonstall,
Governor of the Commonwealth.

On May 9th, the Department of Public Health was authorized to conduct the Survey by the following resolve:

(Chap. 14)

RESOLVE PROVIDING FOR AN INVESTIGATION OF THE DEPARTMENT OF PUBLIC HEALTH, IN CO-OPERATION WITH THE FEDERAL WORKS PROGRESS ADMINISTRATION, RELATIVE TO THE VARIETIES AND PREVALENCE OF CERTAIN KINDS OF MOSQUITOES IN THE COMMONWEALTH OF MASSACHUSETTS.

Resolved, That the department of public health is hereby authorized to investigate, in co-operation with the Federal Works Progress Administration or its successor, the prevalence and the seasonal and geographical distribution of mosquitoes throughout the commonwealth. For said purpose said department may expend for services, other than services of said Federal Works Progress Administration or its successor, and for traveling expenses, supplies, materials and equipment, a sum not exceeding seventeen thousand five hundred dollars, which sum is hereby appropriated from the General Fund or ordinary revenue of the commonwealth in advance of final action on the general appropriation bill, pursuant to a recommendation of the governor to that effect. Said department shall report its recommendations, if any, together with drafts of legislation necessary to carry such recommendations into effect, by filing the same with the clerk of the house of representatives on or before the first Wednesday of December in the year nineteen hundred and forty.

Approved May 9, 1939.

One month later, the Work Projects Administration approved the expenditure of federal funds and the Survey was officially started on June 12th. This investigation was an activity of the Division of Communicable Diseases of the Department of Public Health and was made with the cooperation of the Work Projects Administration which furnished a personnel of one hundred fifty. Collections were started on June 22nd and continued through December 8th, 1939. About 15% of the specimens were submitted by volunteer collectors who were enrolled through cooperating boards of health and other interested agencies.

The Director of the Division of Communicable Diseases, Roy F. Feemster, M.D., Dr. P.H. and the Technical Director of the Mosquito Survey, Vlado A. Getting, M.D., Dr. P.H. planned the organization of the Survey in March 1939. The latter has continued to devote the larger portion of his time to this investigation, has directed the technical work and has compiled the final report. The entire W. P. A. personnel was under the direction of the Project Supervisor, William A. Hogan.

This report is an account of the findings of the investigations made during the Survey. It is divided into three parts:

Part One Mosquito-borne Diseases in Massachusetts
Part Two The Administration of the Mosquito Survey
Part Three Massachusetts Mosquitoes

The first part is an analysis of the 1938 outbreak of equine encephalomyelitis, of malaria, of other mosquito-borne diseases which are prevalent or may become prevalent in the state and of their control. The second part is a description of the organization of the project and of the methods used in the collection, recording and analysis of data. The third part is a record of the facts collected by the Survey and the conclusions which were made concerning equine encephalomyelitis and malaria as a result of these findings. Collections of mosquitoes were made throughout the Commonwealth by the personnel of the Survey. In some areas volunteers greatly increased the number of specimens submitted for identification. From Cape Cod and several other areas, many more collections were submitted through the cooperation of Mosquito Control Projects. These increased collections do not indicate that mosquitoes were more numerous. As a matter of record, mosquitoes were often less numerous in these areas and the larger number of specimens was a result of more extensive and thorough collecting.

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CHAPTER I

EQUINE ENCEPHALOMYELITIS

The Mosquito Survey was organized as a result of the 1938 outbreak of equine encephalomyelitis among humans, animals, and birds in southeastern Massachusetts. The outbreak constituted the first time that the disease was recognized in this State; moreover, it was the first time that equine encephalomyelitis was demonstrated to infect species other than horses and mules. Equine encephalomyelitis is a newly recognized infectious virus disease. Comparatively little is known of this virus which has a broad host selectivity. Its economic importance, however, is great, as it kills thousands of horses and mules every year. Laboratory experiments have demonstrated that many species of small mammals and birds are susceptible. With its recognition among humans, the disease has become a great unsolved problem;a problem which requires study in an effort to arrive at some method for its control.

The mosquito has been proved to be able to transmit the disease experimentally, but, as yet, the role of the mosquito as a natural vector of equine encephalomyelitis has not been established. The objectives of the Mosquito Survey were to collect and determine the various species of mosquitoes present in Massachusetts; to obtain data on the geographical distribution and the seasonal predominance of the different species; to ascertain the possible relationship of these mosquitoes to certain diseases which are transmitted by these insects; and, in particular, to establish whether the presumptive vectors of equine encephalomyelitis are true or merely laboratory vectors.

VARIETIES OF EQUINE ENCEPHALOMYELITIS Equine encephalomyelitis is a disease which may be due to one of four different varieties of virus. However, the clinical picture produced by each variety ranges from a mild and subacute form to one which is fulminating and acute. Similarly, the varieties may be separated by their immunological and serological characteristics,

In the United States,only the western and eastern varieties are known to occur. The western is limited to the area west of the Appalachian Mountains; epizootics of this variety among horses have been characterized by a high attack rate, a low fatality rate, and a subacute form of this disease. The eastern variety, on the other hand, has been known to occur only along the Atlantic seaboard. In 1939, both the eastern and western varieties were isolated in Alabama. Epizootics of the eastern variety are characterized by a low attack rate, a high fatality rate, and a more acute and fulminating type of disease. Both varieties have been demonstrated to infect humans. However, since only a few cases of the disease have been recognized, it is impossible to describe the characteristics of infection with these varieties in man. Nevertheless, with the information on hand, it seems likely that the western variety of this disease in man may be in many instances sub-clinical or mild, whereas the eastern variety causes an acute and fulminating type of disease not unlike that in horses.

EXPERIMENTAL MOSQUITO TRANSMISSION The first successful laboratory transmission of equine encephalomyelitis by the bite of a mosquito was made by Kelser in 1933. This investigator, after many unsuccessful attempts was able to transmit the virus of western variety by the bite of the tropical Aedes aegypti mosquito. During an epizootic of a similar disease along the Chesapeake Bay coast line, Ten Broeck and Merrill observed that cases occurred on farms which were separated by more than ten miles and between which there had been no contact. Moreover, these cases due to the eastern variety were limited to a peculiar geographical distribution. Upon further investigation, they found that this distribution was like that of the common salt marsh mosquito, Aedes sollicitans. The following year, Merrill, Lacaillade and Ten Broeck were able to transmit both the eastern and western varieties to laboratory animals by the bite of this salt marsh mosquito. The significance of this mosquito transmission with the local mosquito whose distribution corresponded to that of the outbreak was at once apparent. During the 1933 outbreak of equine encephalomyelitis in Maryland, Giltner and Shahan triturated in saline and injected into numerous guinea pigs 1,300 mosquitoes of various species collected from a region attacked by the disease. All these experiments were negative. However, with our present knowledge of viruses, it has become evident that these experiments were inconclusive, as the virus in the triturated mosquitoes was dead by the time the experiments were performed.

TABLE I

MOSQUITO VECTORS OF EQUINE ENCEPHALOMYELITIS

Name of Mosquito	Western Variety	Eastern Variety	Occurrence in Mass.
Aedes aegypti	x	x	0
A. sollicitans	x	x	x
A. cantator	x	x	x
A. vexans	x	x	x
A. triseriatus		x	x
A. atropalpus		x	x
A. taeniorhynchus	x	x	x
A. dorsalis	x		x
A. albopictus	x		0
A. nigromaculis	x		0

Many investigators have experimented with the mosquito transmission of this disease. At first, these experiments were difficult to interpret, due to the varying conditions under which they were performed. At the present time, there are seven species of mosquitoes which have been demonstrated experimentally to transmit the eastern variety virus to laboratory animals. The western variety has been transmitted by eight species of mosquitoes. In all instances of transmission, the mosquito concerned belonged to the genus Aedes. Transmission experiments with the other genera of mosquitoes, Culex, Anopheles, Theobaldia, Mansonia, Wyeomyia and Uranotaenia, have thus far been negative. Table I gives a summary of the transmission experiments. It is apparent that some mosquitoes have been shown to transmit one variety of the virus but not the other. So far as is known, there is no biological reason why any species of mosquitoes

should be able to transmit one variety of equine encephalomyelitis virus and not the other. It is believed that eventually experiments will show that if a species can transmit one variety, it can also transmit the other. In all, there are ten species of Aedes mosquitoes which have transmitted the virus experimentally; but it is likely that they are not of equal importance as vectors. Further investigation is needed to determine which species are natural vectors and which are the important ones.

OTHER METHODS OF TRANSMISSION A discussion of the epidemiology of equine encephalomyelitis would not be complete without mention of other experimental and field data. Laboratory experiments repeated by various workers, have demonstrated that equine encephalomyelitis is not transmitted by direct contact. Susceptible animals, which were caged with infected ones, failed to contract the disease in spite of the intimate contact. Field observations during epizootics revealed that multiple infections of horses in the same stable or on the same farm were rare. The evidence is, therefore, against infection by direct contact.

In 1936, Syverton and Berry demonstrated that Dermacentor andersoni, the Rocky Mountain wood tick, was capable of transmitting experimentally the western variety. The continuity of the virus through all stages in the development cycle of the tick, including survival through the egg stage, was definitely demonstrated. There is in ticks, therefore, a potential vector and reservoir, especially during the winter months when cases of equine encephalomyelitis are rare and the ticks are hibernating.

Besides ticks and mosquitoes, experiments on other potential insect vectors have been made, especially on those that habitually bite horses and mules. Riley studied the insect transmission of disease due to filterable viruses and concluded that the stable fly, Stomoxys calcitrans, the horsefly, Tabanus punctifer, and the hornfly, Haematobia serrata, were not capable of being vectors of equine encephalomyelitis.

CONCLUSIONS ON TRANSMISSION The seasonal occurrence of equine encephalomyelitis during the middle of summer and early autumn, and the sudden end of the outbreak with the arrival of killing frosts, strongly support the laboratory evidence of insect transmission. Although there is no evidence that infection in nature is caused by mosquitoes or ticks, both of these are potential vectors. The theory of mosquito transmission merely awaits confirmation by the finding of naturally infected mosquitoes. The proof of mosquito transmission of yellow fever required thirty years; and it is probable that some time may elapse before the mosquito is finally established as the true vector of equine encephalomyelitis.

In a disease with a broad host selectivity such as equine encephalomyelitis, it is not unlikely that the reservoir of the disease may be found in one or more animals. Syverton and Berry suggested that small rodents, the gopher in particular, which they found susceptible in experiments, may be the reservoir. Ten Broeck suggested that birds may be the reservoirs. Several investigators have carried out experiments on the susceptibility of birds and animals to equine encephalomyelitis. Recently, Davis has demonstrated that the eastern variety virus remains in the circulating blood of birds for a period of three or four days. These birds rarely showed more than mild symptoms, and continued their feeding

as though they were perfectly well. These findings suggest that birds may be the natural host of the disease and that the disease has been recently introduced to horses, which have no natural immunity to the disease. The recognition of the occurrence of the disease in man is most recent. Thus far, all infections of man have occurred during the epizootics of the disease in horses; and it is likely that human infections may be an overflow phenomenon of the disease from the natural hosts during pandemics of the disease.

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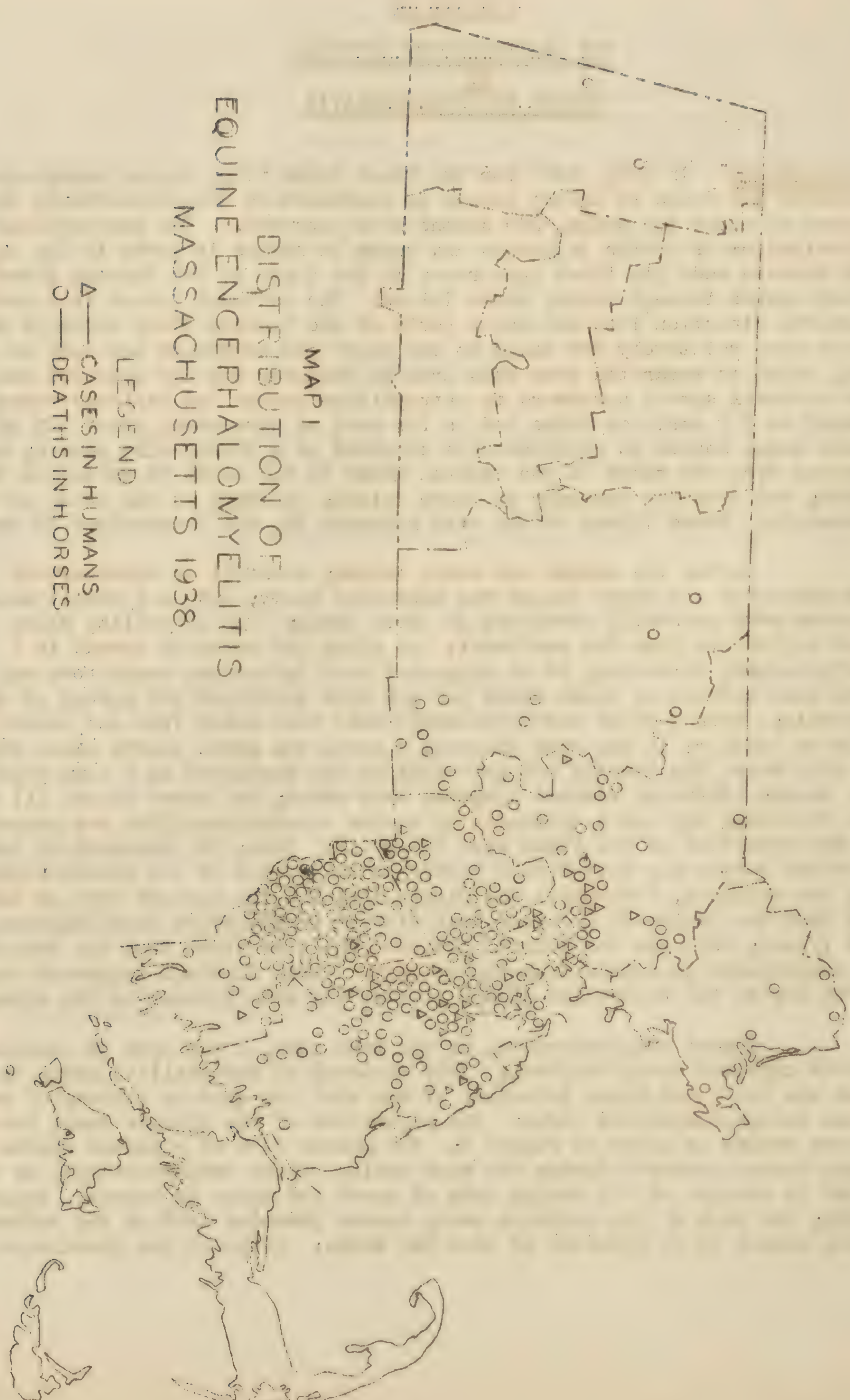
CHAPTER II

THE MASSACHUSETTS OUTBREAK OF EQUINE ENCEPHALOMYELITIS

EPIDEMIOLOGY In July, 1938 for the first known time, equine encephalomyelitis was found to infect horses in southeastern Massachusetts. In the course of about ten weeks, 269 deaths were reported. The geographical distribution of deaths in horses and cases in humans is given in Map I. The disease made its first appearance in the basin of the Taunton River which drains through nearby Rhode Island. The outbreak spread in a northeasterly direction into the upper parts of the Taunton River drainage area. There were relatively few cases to the south and southeast and none on Cape Cod, which is separated from this area by Buzzards Bay and Cape Cod Canal. The outbreak spread northward to metropolitan Boston and isolated cases occurred as far north as Maine and as far west as Worcester. About 70% of the cases among horses in Massachusetts occurred in a thirty mile square, extending from the mouth of the Taunton River in the south to Boston on the north, and from the boundary of Rhode Island, eastward to the coast of Massachusetts. Rhode Island to the west reported 55, and Connecticut 29 cases.

During the summer and early autumn, rainfall in southeastern Massachusetts and Rhode Island was unusually heavy, and as a result mosquitoes were unusually prevalent in these areas. The prevailing winds in that region are from the southwest; and since the outbreak spread in a northeasterly direction, it is suggested that infectious mosquitoes may have been carried by those winds and may have quickened the spread of the epidemic. Horses which were apparently well were moved from one country fair to another; in one such instance a horse was moved thirty miles from an area where the disease was prevalent to the northeast to a town near the coast. Although without symptoms when moved, the horse became ill on the following day and a diagnosis of equine encephalomyelitis was proved by the isolation of the virus from its brain. Thus, the movement of infectious horses may have been a factor in the spread of the disease. During the outbreak, Fothergill and Dingle isolated the eastern type of virus from the brains of a pigeon that died in southeastern Massachusetts, and Tyzzer, Sellards and Bennett isolated the same virus from the brains of ring-necked pheasants from Connecticut. These findings suggested that birds may be the reservoirs of the disease and were factors in its spread.

Almost simultaneously, in the same area, a new type of encephalitis appeared among children. This outbreak of encephalitis among humans was the first known infection of man with the eastern variety of equine encephalomyelitis virus. The prevalence of the disease among horses and humans is given in Figure I. The median date of reported deaths among horses occurred during the week ending August twenty-seventh, or two weeks in advance of the median date of onset for cases in humans. Apparently, the peak of the outbreak among horses preceded that of the outbreak among humans by an interval of over two weeks. Although the prevalence of


MAP I
DISTRIBUTION OF
EQUINE ENCEPHALOMYELITIS
MASSACHUSETTS 1938
LEGEND
Δ —— CASES IN HUMANS
O —— DEATHS IN HORSES

the disease was much greater among horses than among humans, the rise and fall of the outbreak in these groups was the same.The outbreak began slowly without increase for four weeks; and then rapidly reached its peak in two weeks. Remaining at this peak level for about a week, the outbreak subsided more slowly than it began. The last case was reported late in October, sixteen weeks after the beginning of the outbreak.

There were no multiple cases among families, and multiple cases on the same farm or in the same stable were rare among horses.These field observations confirmed experimental evidence that the disease is not transmitted by contact.

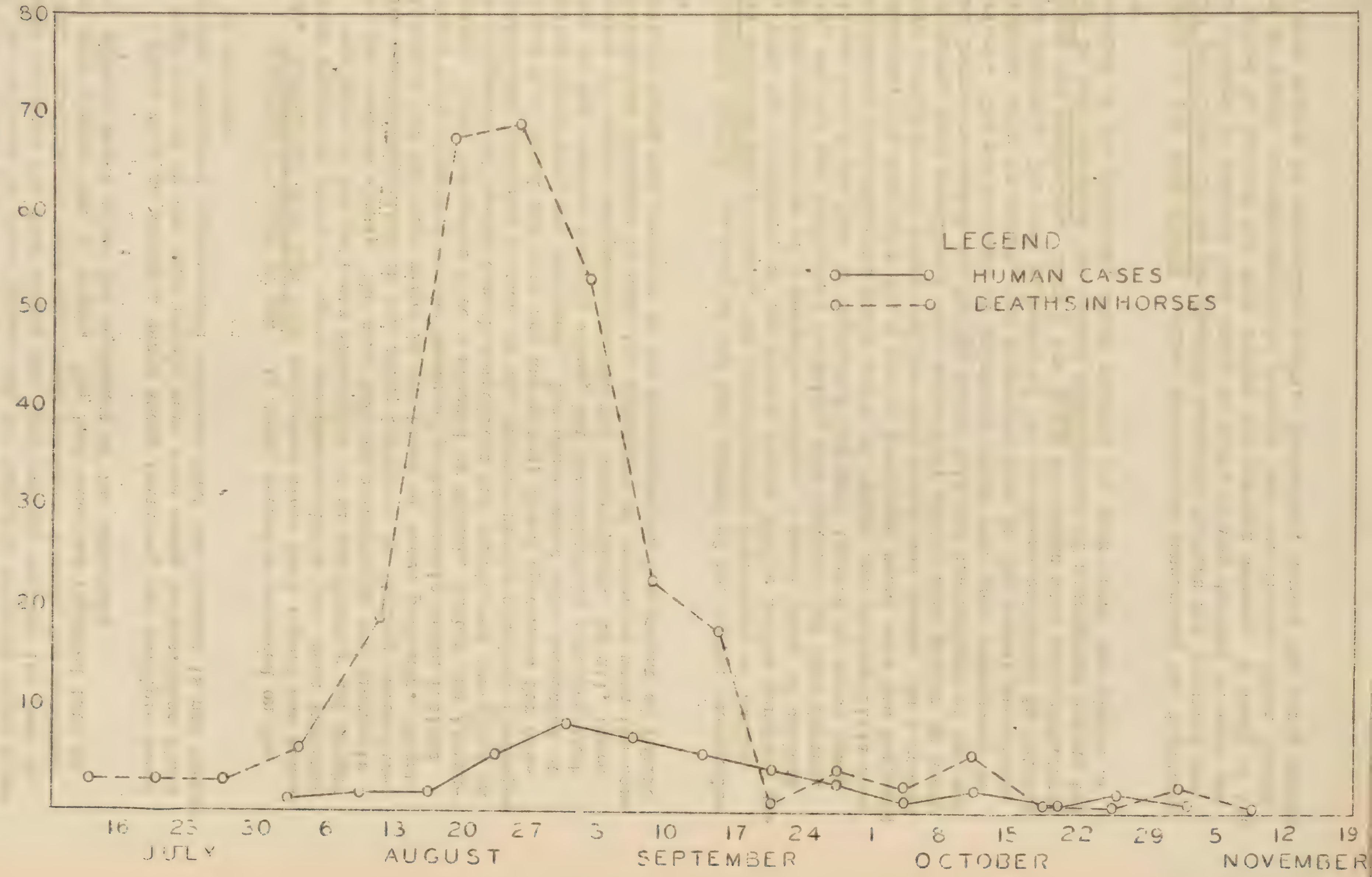
ANALYSIS OF CASES IN MAN In 1938, Feemster reported on the outbreak. Additional data has been collected since this report was made. Forty-four suspected cases of equine encephalomyelitis have been investigated. From nine of the patients Fothergill et al and Webster and Wright isolated the eastern virus. The same workers established the diagnosis of equine encephalomyelitis in ten other instances by finding neutralizing antibodies for the same virus in the blood of these patients. Eight other cases were diagnosed on the basis of pathognomonic brain lesions at autopsy. These autopsies were performed by Branch, Farber and Alexander. A diagnosis of equine encephalomyelitis was considered justified in seven additional patients because of the characteristic clinical findings. These cases were fatal and were not autopsied; blood specimens for neutralization tests were not obtained. Ten other cases were suspected of being due to the eastern variety virus, but investigation revealed that a diagnosis of equine encephalomyelitis was unwarranted. In all, there were thirty-four patients in whom the diagnosis of infection with the eastern variety virus was accepted by the Massachusetts Department of Public Health.

1938 MOSQUITO SURVEY As soon as the true nature of the equine encephalomyelitis outbreak was realized, the Massachusetts Department of Public Health, with the assistance of the United States Public Health Service, undertook the organization of a mosquito survey. A small group of college students, who had had biological training, was employed for this Survey. Collections were begun late in September and were limited to those towns in southeastern Massachusetts where cases of equine encephalomyelitis were most numerous. On September 21, a severe hurricane swept over New England; the storm lasted several hours and the wind damage was great. As a result of this storm, many mosquitoes were destroyed; adults were killed by heavy wind and larvae succumbed due to the heavy rain and disturbance of the water surface. The collections of specimens which were made subsequent to the hurricane are, therefore, not representative of the normal prevalence of these insects. The vast majority of the specimens collected in October were Culex and Anopheles. Only a few Aedes specimens were collected.These findings do not represent the actual distribution of mosquitoes during the continuation of the outbreak, which reached its peak about the middle of August.

OBJECTIVES OF THE 1939 SURVEY Since information concerning the distribution and prevalence of the presumptive mosquito vectors was required before an attempt to control them could be made, it was decided to make another effort to collect the data during the ensuing summer. A study of the history of equine encephalomyelitis reveals that the disease often recurs in the same region in succeeding years. Therefore, during the early months

MASSACHUSETTS 1938

SEASONAL INCIDENCE OF EQUINE ENCEPHALOMYELITIS



of 1939, the Massachusetts Department of Public Health began to make plans for a State-wide mosquito survey. The objectives were to ascertain the true status of mosquitoes as vectors, to find naturally infected mosquitoes if the disease recurred, and to collect data on the distribution and prevalence of the presumptive vector. This information would, then, be applicable to the control of the disease if it were to recur.

As a survey of this type would make collections of all species of mosquitoes, it was decided to utilize this opportunity to collect data on the distribution and prevalence of all mosquitoes; to make a study of the ecological and entomological factors which influenced the breeding of the various species, and to record this information in such a way that it could be used by the State Reclamation Board, which is in charge of all mosquito control work in Massachusetts. In this way the objectives of the Mosquito Survey were enlarged to encompass the collection of all data that could be obtained concerning mosquitoes which were prevalent in Massachusetts, and to determine the relationship of mosquitoes to those diseases which are transmitted by these insects in Massachusetts; namely, equine encephalomyelitis and malaria.

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CHAPTER III

OTHER MOSQUITO-BORNE DISEASES

Equine encephalomyelitis and malaria are the two most important mosquito-borne diseases in Massachusetts. However, there are certain other diseases, some of which are and some of which are suspected of being mosquito-borne and which either occur or may occur in this state.

These diseases have been placed into three groups in Table II. All of them have occurred in the United States and are, therefore, considered as possible invaders of Massachusetts.

TABLE II

Disease with Proved and Suspected Mosquito Transmission in the United States

Proved Mosquito Transmission	Laboratory Mosquito Transmission	Suspected Mosquito Transmission
Malaria *	Equine * Encephalomyelitis	Poliomyelitis *
Yellow Fever **	Lymphocytic * Choriomeningitis	St. Louis • Encephalitis
Dengue •		
Filariasis •		

*   Currently present in Massachusetts

** Formerly " " "

•   Not known to be indigenous in Massachusetts

Diseases With Proved Mosquito Transmission

MALARIA

Malaria is the most widely distributed mosquito-borne disease in the world. It has caused more suffering and death than any other single insect-borne disease. This disease has caused the downfall of great empires, the abandonment of cities and fertile areas, and today is still a great problem especially in tropical and sub-tropical countries.

In Massachusetts malaria has existed from early colonial times. Although the reports of the disease prior to the twentieth century are not wholly reliable, it is apparent that there has been at least three epidemic waves of malaria in Massachusetts.

The first epidemic in Massachusetts took place at the close of the eighteenth century and existed in the western portions of both Massachusetts and Connecticut along the Housatonic River Basin. The second epidemic of malaria appeared in Connecticut in 1830 and spread to western Massachusetts where the disease persisted until about 1870. The third epidemic of malaria began in New Haven in about 1850 and continued to spread northward reaching Springfield in 1870. From there the disease spread in a northerly direction up the Housatonic and Connecticut Rivers. This last epidemic wave continued to harass the state until the end of the first decade of the twentieth century.

Mortality Statistics Deaths from malaria were made reportable as early as 1842. At first these were reported as intermittent fever and remittent fever, from 1855 to 1900 the terminology of this disease was changed to ague and remittent fever, from 1901 to 1911 to intermittent fever and malarial cachexia, and finally, from 1912 to date the disease was reported as malaria.

A study of the reported deaths reveals that there have been several peaks during the past one hundred years. The first peak was reached in 1864 and was associated with an importation of the disease in Union soldiers who returned from the Civil War. A second and much larger increase in deaths due to malaria began to manifest itself in 1880 and continued until 1898 when the deaths began to decrease again. This second wave of malaria, as recorded in these reports, was caused by two factors. The first was an epidemic of malaria in Massachusetts which has already been discussed. This outbreak persisted for many years, and did not completely recede until the end of the first decade of the twentieth century. The disease was associated with an outbreak spreading northward from Connecticut and with the settlement in Massachusetts of immigrants from countries in southern Europe where malaria had a high index. The effect of the Spanish American War on this disease is seen in the peak of 1898; during this year many soldiers returned to Massachusetts, after contracting the disease in Florida and Cuba.

With the turn of the twenteith century malaria deaths began to decrease rapidly and reached a new low in the late twenties. Deaths from malaria average 1.8% during the last ten years. This indicates a case fatality of 8.9% on a basis of the reported cases over the same period.

Morbidity Statistics It was not until 1914, however, that malaria itself was made reportable, when the State Department of Public Health declared it to be a disease dangerous to the public health. At this time malaria was endemic in several places within Massachusetts. From the geographical distribution of these cases it is apparent that there were several outbreaks of the disease within the past twenty-five years.

In 1915, the first year for which the figures are complete, the reported incidence of malaria was the greatest. Since then the disease has a continued decreasing geometric trend and has reached an extremely low level in the past five years. Malaria was prevalent in Boston from 1915 to 1928. However, most of these cases were in sailors who had acquired the infection in the tropics and were hospitalized in this city. Some of the cases, however, were definitely connected with a new sewer project where Italian labor was employed. The high incidence of malaria in Chelsea from 1928 to 1935 is explained by the fact, that the United States Marine Hospital is located here and it received many sailors from foreign countries. The epidemic prevalence of 1918 in Ayer was due to the presence of large numbers of troops at Camp Devens, some of whom were from the south.

In all there are three areas in Massachusetts where malaria has existed within the past twenty-five years. In each instance the disease has ceased to exist in the area more than ten years ago. These three places are:

(1) The Charles River Drainage Area, where the disease was prevalent from 1915 to 1921. Here the disease apparently occurred first in Natick and Newton and spread to the neighboring communities of Dedham, Framingham and Wellesley. The town of Dedham has a large Italian colony; and this is also true of Milford in the upper part of the Charles River where malaria was prevalent from 1919 to 1924. It is important to note that malaria was not made reportable until 1914 and, consequently, there is no data on its incidence in this area prior to that year. Older residents of this Charles River Basin state that malaria was quite common in their childhood during the first decade of the twentieth century. It is not unlikely that it may have been a hangover from the epidemic wave of the last quarter of the nineteenth century. Unfortunately, there were many more cases of malaria in this region than were reported.

(2) The second region where malaria seems to have been endemic from 1915 to 1921 is the Blackstone River Basin, in particular the towns of Uxbridge, Douglas and Northbridge.

(3) The third endemic region can be roughly described as the Taunton River Basin. Here malaria persisted from 1915 to 1922. The same etiological factors were responsible for disease in these regions, as in the Charles River Area.

<u>Malaria Acquired in Massachusetts</u> The Massachusetts cases can be divided into two major groups, intra-state infections and out-of-state infections. An analysis of the cases reported during the ten years 1930 to 1939 inclusive reveals that the vast majority of the cases are out-of-state infections. These are principally among immigrants who acquired the infections prior to their arrival in Massachusetts, travelers who became infected during their sojurn outside of the state, and among sailors who acquired the disease in the tropics and sub-tropics.

The second groups of cases consisted of those who acquired their infection within the boundaries of Massachusetts. These native infections

are composed of three categories of patients. The first, and largest, consists of therapeutic infections among patients in mental disease hospitals; second, and smallest, is the group which received accidental infections by the medium of transfusion from a person who was an unsuspected carrier of the malaria plasmodium in his blood stream; third, and most important, were the naturally acquired infections, which presumably resulted from the bite of infectious mosquitoes. Within the ten year period studied, 1930-1939, there were only eleven instances where natural infection within Massachusetts was probable. These cases were scattered throughout the Commonwealth and there is no evidence to suggest that there was any connection between them. In several instances, namely, two children who acquired the infection during 1938, there were malaria cases in the same or a neighboring household. However, the source of the infection in the other nine cases has not been established.

YELLOW FEVER

Yellow fever is transmitted principally by Aedes aegypti. Experimentally, twenty-one other species of mosquitoes, Simmons, have been demonstrated to transmit this disease. However, neither the natural vector nor the experimental vectors are indigenous to Massachusetts. In colonial times yellow fever appeared in New England. It was brought to port cities by sailing vessels which came from areas in the tropics and sub-tropics where yellow fever was endemic. The mosquito, Aedes aegypti, was able to survive on board these ships, breeding in water casks. Under favorable meteorological conditions and a temperature of over 72° F Aedes aegypti were able to survive and breed, and transmit the virus in northern climates until the arrival of colder weather. In this way, yellow fever appeared characteristically in the summer and disappeared early in autumn. The outbreaks were limited to the vicinity of the seaports to which the vector was brought by the vessels. As Aedes aegypti is unable to survive through the severe winters of the United States, yellow fever did not reappear on subsequent years unless it was reintroduced into the same region. Yellow fever may reappear in Massachusetts only if infected Aedes aegypti are imported, if these mosquitoes breed in large enough numbers to be temporarily established, and if the infected mosquitoes bite people, who, in turn, infect Aedes aegypti. However, the importation of yellow fever is highly improbable, not only because of the lack of breeding places on modern steamships, but chiefly because of the efforts of the United States Public Health Service, which quarantines all vessels and airplanes which come from areas where the disease is endemic, or takes such measures as to ensure the destruction of Aedes aegypti on board ships or planes.

DENGUE

Dengue has never been known to exist in Massachusetts, although it has spread in epidemic waves through several of the southern states. It is transmitted by Aedes aegypti and Aedes albopictus, both of which are tropical or sub-tropical mosquitoes. As with yellow fever, the mosquito does not become capable of transmitting the virus until after an extrinsic period of incubation. The vector remains infectious for life and is, apparently, not injured by the infecting agent. Dengue, like yellow fever, can occur in epidemics only where

there is a certain numerical relationship between the vector, the number of cases and the number of susceptibles in the community. This disease may appear in Massachusetts under the same conditions as yellow fever. To date there is no record of its existence in Massachusetts, but due to its proximity it seems that, statistically, the chances of its introduction into the state are greater than that of yellow fever.

FILARIASIS

Filariasis, due to Wucheria bancrofti, is transmitted, principally, by Culex fatigans and Aedes variegatus. In all twenty-nine species of the genera Culex, Aedes, Mansonia and Anopheles have been demonstrated to transmit the disease experimentally. This disease is, in the main, restricted to tropical and sub-tropical regions. However, indigenous cases have occurred in South Carolina. Since most infections do not present any clinical manifestation, the prevalence of the disease is difficult to estimate. The disease has not shown any evidence of extending to neighboring areas, and the chance of this disease reaching Massachusetts is very small.

Diseases in which Mosquito Transmission has been Demonstrated

EQUINE ENCEPHALOMYELITIS

Equine encephalomyelitis has been discussed in great detail. The laboratory demonstration of mosquito transmission is confirmed by epidemiological observations. To date, naturally infected mosquitoes have not been found. However, it was not until 1931 and 1938 that mosquitoes naturally infected with yellow fever were collected, years after the mosquito transmission of this disease was demonstrated by Reed. The collection of mosquitoes naturally infected with equine encephalomyelitis may not be accomplished for many years.

LYMPHOCYTIC CHORIOMENINGITIS

Lymphocytic choriomeningitis, a newly recognized virus disease, has been experimentally transmitted with Aedes aegypti by Coggeshall. The disease was first described by Wallgren in 1925. The virus was isolated by Armstrong and Lillie in 1934. The disease infects all ages and both sexes. Blackfan describes it as a seasonal disease with a majority of the cases occurring during winter and early spring. Experiments have demonstrated that although infection may be acquired through an abraded skin, that it is not spread by direct contact. Evaluation of the above experimental mosquito transmission is not yet possible. If this disease has a mosquito vector, it must be some mosquito other than Aedes aegypti, as it has occurred in regions where this species is not found. The possibility of other arthropodal vectors must be considered.

To date there is no report of the isolation of the virus of lymphocytic choriomeningitis from man in Massachusetts. Several clinical diagnoses have been made, but none have been reported as confirmed by serological examination. Laboratory workers who have handled the disease, have developed immunity as demonstrated by mouse protection tests. In investigations of routine sera from diagnostic laboratories, several positive protection tests have been obtained. Naturally infected

mice have been demonstrated in Massachusetts. Epidemics of the disease have occurred in Los Angeles. Whether or not it may occur in Massachusetts in epidemic form is impossible to foretell. The mosquito transmission of lymphocytic choriomeningitis needs confirmation before it can be accepted. If Blackfan's observation of the peak incidence of the disease in winter and early spring is confirmed, then some other arthropodal vector may be responsible for its spread. The transmission of this disease by Dermacentor andersoni has been reported by Shaughnessy and Milzer. They were able to infect guinea pigs by the bite of nymphs which had been infected in the larval stage. Feces from infected ticks, when rubbed into the abraded skin of guinea pigs, likewise transmitted the disease.

Diseases with Suspected Mosquito Transmission

POLIOMYELITIS

Poliomyelitis has been suspected of insect transmission because of certain epidemiological features. Several arthropods as body lice, Pediculus vestimenti, head lice, Pediculus capitis, bedbugs, Cimex lectularis, fleas, flies, Calliphora vomitoria and Musca domestica have yielded negative results in attempts to isolate the virus from their bodies. Attempts to transmit poliomyelitis by bites of insects have been uniformly negative.

Noguchi and Kudo attempted to transmit poliomyelitis to Macacus monkeys by Culex pipiens. They fed young larvae with the virus in the polluted water in which they were growing and allowed the emerged adults to bite monkeys. These experiments were negative. Attempts to transmit the disease by the bite of mosquitoes who had formerly fed on infected monkeys were likewise negative in experiments conducted by these investigators. Flexner and Clark were unable to demonstrate the survival of poliomyelitis virus in Culex pipiens, Aedes sollicitans and Aedes cantator after they had fed upon infected monkeys. Simmons, Kelser and Cornell unsuccessfully attempted to transmit poliomyelitis to monkeys by Aedes aegypti.

The mosquito transmission of poliomyelitis is highly improbable because of the very nature of the disease. The virus has not been demonstrated to be present in the blood of human beings at any stage of the disease. The inconstant presence of even small amounts of virus in the blood of experimentally infected monkeys, the large amount of virus required to produce even inconstant infections by the intravenous route, and the contemplation of the relatively small amount of blood which a mosquito could transfer even after an interrupted meal exclude the theory of mosquito transmission.

Although the majority of cases of clinical poliomyelitis appear in the summer, the disease continues throughout the year. Therefore, the mosquito, which, except for a few lethargic adults, is hibernating, cannot be classified as the vector; this fact is confirmed by winter epidemics of poliomyelitis. If poliomyelitis is a mosquito-borne disease, the vector must be world wide in distribution, as the disease has occurred on all continents. To our knowledge, there is no insect-

borne disease which has such a universal distribution. Our observations here in Massachusetts indicate that there is no correlation between the prevalence of mosquitoes and the existence of the disease. 1938 was a year when mosquitoes were unusually prevalent, yet poliomyelitis remained at a very low subepidemic level of only 18 cases, as compared with the tricentral mean of 168 for the past nine years. In 1939, mosquitoes were much less prevalent than usual, nevertheless, the number of poliomyelitis cases increased to 76, four times as great as in 1938. If this disease were mosquito-borne, the opposite phenomenon would be expected. In conclusion, it may be said that all epidemiological and experimental investigation indicates that poliomyelitis is not transmitted by mosquitoes.

ST. LOUIS ENCEPHALITIS

St. Louis encephalitis is a specific virus disease which can be serologically distinguished from other encephalitides. This disease has recurred for several years in the middle and far western states. It is typically a late summer and early autumn disease. In 1933, the famous St. Louis outbreak started early in August, reached a peak early in September, and ended with the onset of cold weather in October. Meteorological conditions were unusual at this time in St. Louis. The city experienced less rain in that summer than in any year since 1837. Many open drains containing stagnant water became breeding places of mosquitoes. Because of the abundance of these insects during the outbreak, investigations were undertaken to determine if mosquitoes can transmit the disease. Simmons and Cornell fed Aedes aegypti on patients admitted to the hospitals of St. Louis, and thereafter permitted the mosquitoes to bite experimental animals. All these experiments were negative. Leake, Musson and Chope carried out more extensive experiments with Culex pipiens, Anopheles quadrimaculatus and Aedes aegypti. The results were all negative. Leake concludes: "In spite of entire failure under a wide variety of experimental conditions, we cannot say that the possibility of transmission of encephalitis by mosquitoes in nature is finally disproved." Later, Webster, Clow and Bauer demonstrated the survival of this virus for life in Anopheles quadrimaculatus. Mitamura, Yamada et al were able to transmit both the St. Louis encephalitis and the Japanese B encephalitis by Culex pipiens var. pallens. This work, however, needs confirmation before it can be accepted. Lumsden has reviewed the epidemiology of the St. Louis outbreak and concluded that Culex pipiens might have been responsible for the transmission of the disease. Reporting upon an outbreak of St. Louis encephalitis in California, Howitt remarks that mosquitoes were abundant in the regions where the disease was prevalent.

To date St. Louis encephalitis has not been reported in Massachusetts. However, its recognition in such widely separated areas as Indiana and California indicates that the disease has involved hitherto unsuspected areas.

The problem of mosquito transmission of St. Louis encephalitis remains unsolved. The negative experiments cited above are inconclusive evidence, as the insects were, of necessity, fed upon patients who were admitted to hospitals and, therefore, well advanced in the course of the disease. If the virus were present in the circulating blood only during

the early stages of the disease, the experiments were, per force, negative. Further investigation must determine the role of the mosquito in this disease. Its seasonal distribution and the epidemiological observation indicate that St. Louis encephalitis may be mosquito-borne.

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CHAPTER IV

THE CONTROL OF MOSQUITO-BORNE DISEASES

The control of any mosquito-borne disease is based on one or more of the following procedures:

I Control of the mosquito vector
II Protection of man and animal from the bite of infected mosquitoes
III Immunization of susceptibles
IV Removal of sources of infection of mosquito vectors by
  a. Isolation of cases
  b. Treatment of carriers
V Prevention of entry of the mosquito vector and possible sources of infection into areas as yet unaffected by the disease

All these methods are not applicable to every mosquito-borne disease. The diseases under discussion are listed in Table III with a notation on the application of the various control methods.

I Mosquito Control Certain conditions are necessary before a mosquito-borne disease can become epidemic or reach a high endemic index. One of these conditions is the existence of a certain numerical relationship between the hosts, vectors and susceptibles. When this numerical relationship is upset by a reduction of the number of vectors, the disease ceases to be epidemic and rapidly declines either arithmetically or geometrically, depending upon the interrelation of many related factors. It becomes apparent that a moderate reduction in the number of mosquitoes below the critical level will markedly reduce the prevalence of the disease in an area where there are many immunes, but in a region with many susceptibles, the reduction below the critical level must be much greater. This concept was developed by Ross who applied it to malaria. Carter and Gorgas applied it to yellow fever.

The bionomics of mosquitoes are such that control measures must be designed to eliminate or control the larvae or the adults. The measures which are most effective in any area depend upon the local factors and upon the genus and species of mosquitoes concerned. It is impractical and uneconomical to attempt to control all mosquitoes. The control measures must be directed against that species which it is desired to reduce below the critical level. Therefore, in order to insure effective control measures, it is important to understand the bionomics, breeding habits, and seasonal and geographical distribution of the species that are concerned with the transmission of the disease. Since local circumstances vary, it is necessary that a mosquito survey be made before control measures are introduced into a new area for the purpose of controlling mosquito-borne disease. Even in controlling mosquitoes as a nuisance, it is necessary to determine their bionomics before an economical and efficient nuisance control can be expected.

Mosquito control has been effective in malaria and yellow fever.

There has been considerable less experience in the effectiveness of this method in dengue, but since the principal vector of this disease is the same as for yellow fever, there is every reason to believe that mosquito control will prove just as effective. In filariasis, this method has also proved to be effective where it can be applied. To date, there has been no notable effort to control the vectors of equine encephalomyelitis. Theoretically, this method should be effective; but the natural vector of this disease has not yet been determined, and epidemiological and entomological investigations are needed before this method can be applied. The collection of this data is the primary objective of this mosquito survey.

TABLE III

APPLICATION OF CONTROL METHODS TO MOSQUITO-BORNE DISEASES

DISEASE		Methods of Control* I	II	III	IV a	IV b	V
Malaria		xxx	xx	0	xx	xx	0
Yellow Fever		xxx	xx	xx	xx	0	xxx
Dengue		xxx	xx	0	0	0	xx
Filariasis		xxx	xx	0	0	0	0x
Equine Encephalomyelitis	Horses	x	xx	xxx	0x	0	0
Equine Encephalomyelitis	Humans	x	xx	0x	0	0	0

*Methods
- I Mosquito Control
- II Protection from Mosquito Bites
- III Immunization of susceptibles
- IV Removal of sources of infection
  - a. Isolation of cases
  - b. Treatment of carrier
- V Prevention of entry into new area

xxx Proved effective
xx Only partially effective
x Theoretically effective
0 Not applicable

II Protection from Mosquitoes Effective protection from the bites of mosquitoes can be accomplished only under very limited conditions. Screening, and avoidance of unnecessary exposure, are the methods most effective. Spraying in houses, the application of mosquito repellants and swatting of adults are adjuvants. If this method were to be effective, animals and man would necessarily have to remain behind screens at all times. Since this is a physical impossibility, the protection against mosquito bites is only partial. This method is about equally applicable in all mosquito diseases; the differences are dependent upon the habits of the adults of the species

concerned.

III Immunization of Susceptibles Specific immunization has proved effective in yellow fever. It is, however, not yet available to the public in all endemic areas. Although the vaccine is a live attenuated virus, there has been no resumption of virulence in over two million vaccinations performed in Brazil. Whitman demonstrated that mosquitoes which bit vaccinated persons did not infect monkeys on subsequent biting. Unfortunately, immunity is temporary and annual revaccination is required.

In equine encephalomyelitis, a vaccine produced from formolized virus grown in chick embryos, has proved effective in the protection of horses. As yet, this vaccine is not applicable to man, except for laboratory workers, due to severe reactions which have been encountered. Moreover, the risk of exposure to the disease has been so small that community immunization has not been indicated. Vaccination of horses must be repeated annually as immunity is temporary. Mohler attributes the decreased incidence of this disease in 1939, in part, to the vaccination of horses.

There is no specific immunization against the other mosquito-borne diseases. The prophylactic use of quinine in malaria is an attempt to destroy the plasmodium as soon as it is introduced into the blood stream.

IV Removal of Sources of Infection is effective only to a limited extent. Cases of the disease, with the infecting agent in the circulatory blood, may act as foci of infection for vectors. Therefore, it is, theoretically, good preventive medicine to isolate these patients in mosquito proof quarters. Except for malaria and filariasis, which are, respectively, due to a protozoan and a helminth, the remainder of the mosquito-borne diseases are due to a virus which remains in the blood stream for a very short time, and which, in many instances, disappears from the blood stream soon after the disease manifests itself.

Malarial gametocyte carriers are the foci of outbreaks of the disease in new areas. Filariasis is often symptomless. As filaria may remain in the blood for prolonged periods, these carriers may act as sources of vector infection. Malarial carriers may be eliminated by adequate treatment, but filarial carriers remain permanent, for there is no known effective drug therapy in this disease.

V Prevention of Entry into New Areas This is a method which is applicable to all infectious diseases. The principals of isolation and quarantine are utilized in every community. In the case of certain diseases, especially those with a wide host selectivity, the prevention of the spread of a disease becomes more difficult. This feature is well illustrated in the case of yellow fever. The disease was apparently controlled by the use of the usual methods and isolation and quarantine on a community basis. Suddenly, it became apparent that jungle yellow fever was due to the persistence of the disease in other hosts and vectors.

Equine encephalomyelitis has an even greater host selectivity. Its spread may be due to vectors or hosts, Since the hosts include animals and birds, the geographical limitation of this disease becomes a difficult problem.

Malaria and filariasis are usually spread by hosts who are not known to be infected. In modern civilization and rapid transportation, it is practically impossible to eliminate the travel of such individuals.

Conclusion In summary it may be said that when control methods are dependent upon control of man, only limited success may be expected, as some individuals are uncooperative.

The most effective method in the control of mosquito-borne diseases has been the reduction of vectors to below the critical level which will maintain the disease.

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CHAPTER V

ORGANIZATION

The Mosquito Survey was organized as a separate activity of the Division of Communicable Diseases in the Massachusetts Department of Public Health. The director of the Division of Communicable Diseases was responsible to the Commissioner of Public Health for activities of the Survey. In direct charge was the technical director who was responsible for the administration of the Survey, the analysis of the findings and the compilation of the final report.

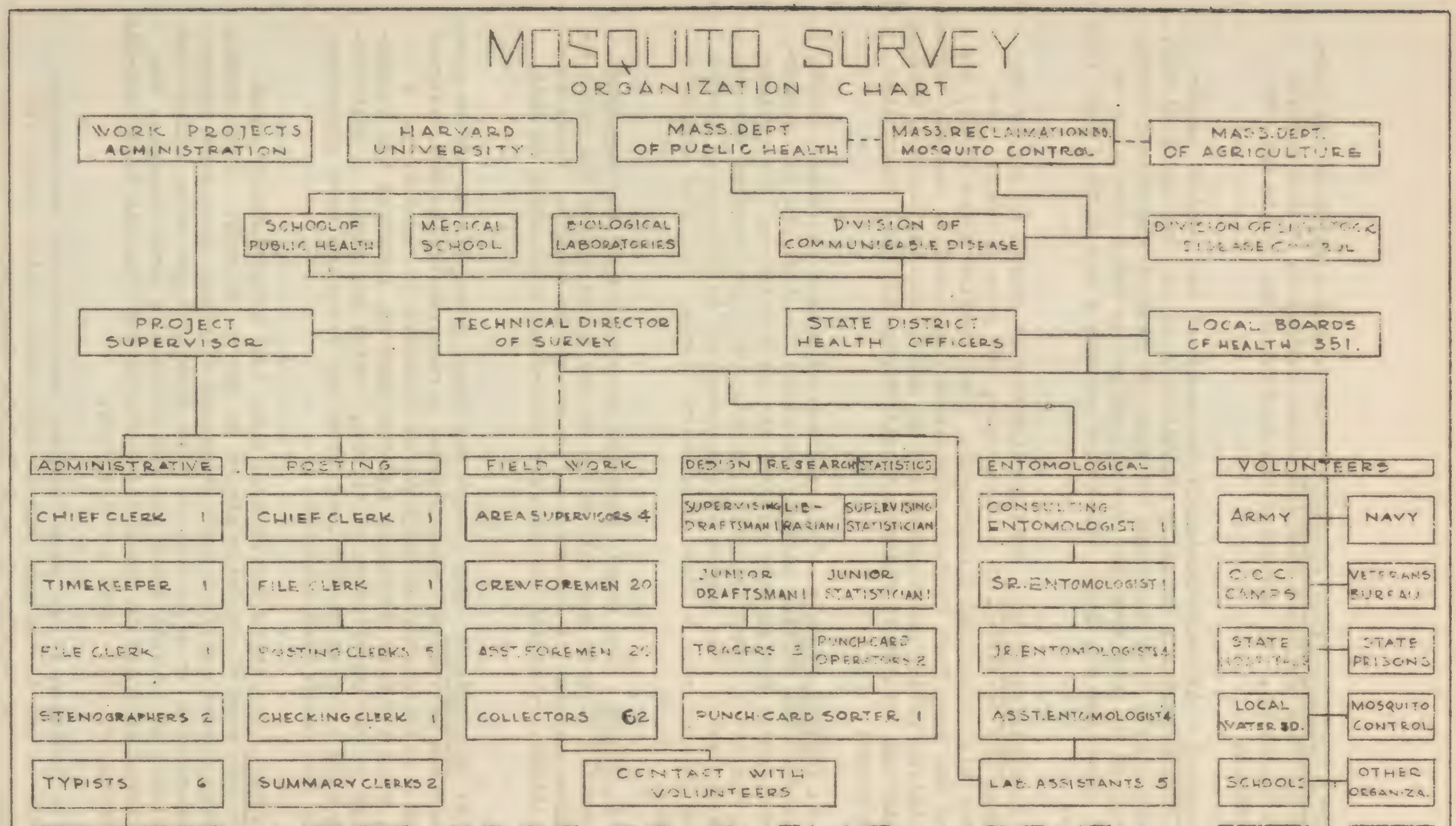
Although it was an activity of the Department of Public Health, the Mosquito Survey was made possible through the cooperation of the Work Projects Administration. Various federal, state and private organizations participated in the Survey's activities. Exclusive of the technical director and the entomologists, the personnel of the Survey were all Work Projects Administration employees.

The Massachusetts Department of Agriculture, through the Division of Livestock Disease Control and the Massachusetts Reclamation Board, cooperated in the activities of the Mosquito Survey. The Massachusetts Reclamation Board, composed of members from the Department of Public Health and Agriculture, is in charge of mosquito control projects in the Commonwealth. This Board, through its vast knowledge of mosquitoes in Massachusetts, assisted in laying out the program of the Survey.

Harvard University, through the Medical School and School of Public Health, gave active help. The Department of Preventive Medicine and Epidemiology, the Department of Bacteriology, and the Division of Biology assisted the Survey by furnishing quarters and some equipment. Members of the several faculties took part in the training course of the field personnel.

STATE PERSONNEL The Survey itself was divided into two parts; the state employees, and the Work Projects Administration employees. Of these, the state employees formed the smaller portion, consisting of the entomological staff and several members of the Division of Communicable Diseases, who, although not actual members of the Survey, rendered valuable assistance during the months of organization. The organization chart on the following page, clarifies the exact status of the Survey personnel and of the various volunteer cooperating groups.

The entomological staff was composed of a consultant entomologist, chief entomologist, four entomologists and four assistant entomologists. In addition to their taxonomic activity, the entomologists assisted in the training of the field personnel, made special collections in the field, aided in the supervision of technical details, revised the identification key, and made permanent collections of mosquito adults and larvae for research and teaching purposes.



MASS. DEPT. OF PUBLIC HEALTH

DIVISION OF COMMUNICABLE DISEASES
IN COOPERATION WITH THE
WORK PROJECTS ADMINISTRATION.

WORK PROJECTS ADMINISTRATION PERSONNEL The second portion of the personnel was the Work Projects Administration employees, with a project supervisor in charge. It comprised two sections, the office and the field personnel.

Office Personnel Although nominally in charge of the project supervisor the office work was actually administered by the two chief clerks. This was especially true on occasions when the project supervisor found it necessary to be away from the central office on trips requiring an absence of more than one day. The office personnel was divided into four categories:

1. Administrative This portion was in charge of one of the chief clerks, and consisted of a timekeeper, two stenographers, five typists, one file clerk and a messenger. Their duties were: first, the handling of the many Work Projects Administration details; second, correspondence; third, filing and supervision of survey sheets; fourth, mailing of pamphlets and letters to volunteer collectors, and many other miscellaneous tasks.

2. Posting of Data This portion comprised one chief clerk, one file clerk, five posting clerks, one checking clerk and two summarizing clerks, whose duties were to post the collection and identification data, and after summarizing it, to code it in preparation for the punch card analysis. The number of the personnel in this group varied greatly and was enlarged to more than thirty during the final analysis of the data.

3. Supply The supply room was concerned with the preparation of material used in the collection of specimens and in the preparation and mimeographing of literature for use by the Survey. There were one chief laboratory assistant and four laboratory assistants in this group.

4. Specialists The fourth and final group of the office personnel consisted of various specialists. A research worker was assigned to build up a bibliography on subjects of interest to the Survey. A draftsman, with a junior draftsman and two tracers, assisted the technical director in the compilation of charts, tables and maps. A statistical clerk, with a junior statistical clerk and two punch card operators, assisted in the punch card analysis.

Field Personnel The state was divided into four approximately equal areas, one area supervisor being placed in charge of each. These areas, in turn, were further divided into districts of which there were twenty in the Commonwealth or an average of five districts per area. Each district consisted of several towns and was assigned a crew foreman. The number of towns included in these districts varied from six to twenty-six with an average of 17.6 towns per district.

In addition to the crew foreman, each district was assigned a field crew of one to six men, the average number being four. The actual number of men working in each district depended on the number of

towns in the district. An example is Franklin County which was incorporated as District #16, comprising twenty-six towns. This district was in charge of a crew foreman and six crew members. The state was divided into districts and the districts were divided, originally, into four portions; each portion was to consist of a single day's work, as the original plan of the Work Projects Administration was to work four days a week. Shortly after the project started, however, new Work Projects Administration regulations were enforced, changing the work schedule of the project to a five-day week program. The districts were, therefore, divided into five portions one portion to be covered each working day of the week. In this way, each district was covered completely once a week. Wherever possible, one man was to cover one town in one day. However, with the introduction of a five-day week, this plan had to be modified.

The field work was under the direction of the four area supervisors. Each of these was responsible for the collection of data and specimens in his area. His work consisted of periodical visits to each district, during which he supervised the administration of the district, checked workers in the field, left supplies for the coming week and picked up collections which were made during the preceding week. He checked the district records, survey sheets, and volunteer W. P. A. collections. Once a week a conference was held at headquarters in Boston. Here the supervisors received supplies for the forthcoming week, were given instructions concerning problems which had arisen, and left collections which they had obtained from each district.

Each crew was under the direction of a crew foreman who owned an automobile which he used to contact local boards of health, Boy Scouts, Y.M.C.A. and other summer camps and schools. Whenever possible, he arranged his schedule so that he worked in the same towns in which his crew was collecting. He acted as contact man between the Mosquito Survey and such organizations as were to do volunteer collecting. Enlistment of volunteer collectors by public speeches and demonstrating was one of the more important duties. Supervising and checking the work of the crew formed a second important item in the foreman's schedule. He checked the crew in and out in the morning and afternoon, gave them supplies at the beginning of the day and collected the specimens in the evening. All specimens were inspected for the presence of larvae or adults and for correct labeling and filling of the vials. Survey sheets were checked for completeness and accuracy. The foreman kept each crew member's collections separate and turned these over to the supervisor with a report as to the number of collections made by each man, each day of the week. The third important duty of the crew foreman was keeping accurate and complete records. He made a copy of the survey sheet; the original was kept and filed at the district headquarters and the copy was sent to the central office in Boston. It was the foreman's duty to see to it that each crew member sent in the required weekly reports and that he himself submitted summary reports for the work of the crew each week.

The assistant crew foreman was responsible in the absence of the crew foreman. Each assistant foreman owned and operated an auto-

mobile in which he transported the crew. The assistant foreman travelled over a designated route and dropped off crew members at designated points, one in each town. Thereafter, he proceeded to the farthest and usually the largest town where he collected as did other members of the crew, with the exception that he travelled from point to point in his automobile.

The chief duties of the crew members were the collection of adults and larvae and the establishment of collection points. Crew members met at a designated point in each district before nine o'clock in the morning. By nine o'clock the crew had received such supplies as it needed for collections that day, and then was transported to towns which were to be covered during the day's work. One by one they were dropped off in different towns where they proceeded on foot between collection points. According to the W. P. A. regulations, the crew worked five six-hour days per week. There was a one hour lunch and rest period between twelve and one o'clock. On the return trip at the end of the day, the assistant foreman arranged his schedule so that he met the last crew member at three o'clock. This was in accordance with W. P. A. regulations. The remainder of the trip was made on the worker's time. In certain instances, some crew members were requested to visit summer camps in an effort to enroll volunteers. Such instructions were given by the supervisor or foreman.

The project supervisor was responsible for the work of all the Work Projects Administration personnel. However, because of the technical nature of the work, it was often desirable to have the technical director explain the particular task concerned, to the worker, individually. On all such occasions, the supervisor and any other persons concerned, were called together and the situation was explained to the group. In this way, the project was able to accomplish more work in a shorter period of time, and, with the cooperation of the project supervisor, to circumvent many delays which would have otherwise intervened.

In summary, the field personnel consisted of one project supervisor, who was also in charge of the Work Projects Administration office personnel, four area supervisors, twenty crew foremen and eighty-two crew members. The total field personnel numbered one hundred and seven.

<u>VOLUNTEER COLLECTIONS</u> A substantial portion of the collections made during this Survey were obtained by volunteers. Approximately 10% of the total collections and about 50% of the adult collections were made by them.

Volunteer collectors were enrolled systematically upon application blanks furnished by the Survey. The names and addresses were filed in the central office and each collector was given an identifying number. Upon receipt of an application, a letter was sent to the volunteer collector informing him of his identification number and the source of supplies. The application blank contained information about the Survey. In addition to the letter, bulletins on mosquitoes and encephalitis and from time to time a pamphlet entitled "Massachusetts Mosquitoes" were sent to the volunteer collectors. In all, there were five of

these bulletins during the season.

The enrollment of volunteer collectors was begun by the personnel of the Division of Communicable Diseases of the Department of Public Health. Epidemiologists and District Health Officers contacted the three hundred and fifty-one local Boards of Health and arranged for visits by employees of the Mosquito Survey. At the same time, samples of literature and supplies were left at each Board of Health.

During the first few months of the Survey, crew foremen in each district re-visited the Boards of Health, left additional supplies, and collected such specimens as had been obtained. Periodically, Boards of Health were visited throughout the continuation of the Survey. During the summer months, the best cooperation from volunteer collectors was obtained in summer camps, state institutions and federal institutions. Although summer camps were, as a rule, of comparatively short duration, valuable contributions were made by many of them. Boy Scout and Girl Scout Camps did excellent work. Several of the state hospitals and the Department of Mental Hygiene made valuable contributions. The United States Navy submitted collections throughout the season from several places along the coast line.

The Brookline Board of Health, in charge of the Mosquito Control Project of this town, made regular collections from the Survey from May through October and brought the specimens to the laboratory. The Cape Cod Mosquito Control Project was perhaps the largest contributor of volunteer specimens during the Survey. The supervisor and the entomologist of this project collected specimens for us and arranged for their workers to do likewise. In addition to the collections which the Cape Cod Mosquito Control Project personnel itself made, the workers enrolled many volunteer collectors and submitted numerous specimens to us from Barnstable County. The State Reclamation Board personnel made numerous collections, especially during the earlier part of the season. The Nantucket Mosquito Control Project also assisted the Survey in making collections on the island of Nantucket.

All the volunteer collecting carried out by organizations in the state other than those already mentioned above, was in direct charge of the personnel of the Survey. Supervisors and crew foremen met with various intra-state groups, and gave lectures and field demonstrations. Approximately one-half of the time of the crew foreman was devoted entirely to the organization of volunteer collectors. Such specimens as were picked up by volunteers, were usually brought to a place designated by the local Board of Health, and then collected periodically by a representative of the Mosquito Survey. New supplies for volunteer collectors were likewise left at these places, and were always in sufficient quantity to meet local demand.

The collections made by the volunteers were particularly important in that they consisted principally of adult mosquitoes, whereas the collections made by the personnel of the Survey were, in the main, larvae. Moreover, one species, Psorophora ciliata, was collected only by volunteer collectors. Although the total number of collections made

by the volunteers was comparatively small, we feel that better results can be obtained in the future by organizing the Survey in the spring.

During the months of September and October the Survey personnel was able to visit teachers and various nature groups in some of the high schools throughout the state. The response from these groups was most heartening and resulted in an appreciable increase in the number of volunteer specimens submitted. It is our opinion that if the high schools are contacted early in the spring, the number of volunteer collections will nearly equal, if not exceed, the number submitted by the Survey personnel.

In all, over 8000 collections were made by the volunteers. Unfortunately, during the summer there was a drought in Massachusetts, and as a result, mosquitoes were comparatively scarce. This was in marked contrast to the summer of 1938, when mosquitoes were unusually prevalent due to the heavy summer rains. It is our feeling that had mosquitoes been a real nuisance during the summer of the Survey, the response from volunteers would have been much greater.

CHAPTER VI

COLLECTION OF SPECIMENS

COLLECTION POINTS Most of the plans for the Mosquito Survey were drawn up during the early part of the spring of 1939. Since it was desirable to begin the Survey as soon as appropriations were made, it was necessary to have on hand sufficient material to enable the field workers to begin immediate mosquito collections. As it was our desire to make regular periodical collections at prescribed points throughout the Commonwealth, such places as we thought would be permanent collection points had to be selected.

A collection point was defined as an area 100 yards in radius, about some permanent landmark as a center. Such a collection point may have been in the woods, meadow, or at the edge of a large pond. In the last instance, the center which was chosen was a prominent, easily identified landmark on the shore, and the collection point area extended 100 yards in either direction along the shore and 100 yards inland. Before field work was begun permanent collection points were selected by two methods. 1. Maps of Massachusetts, prepared by the U. S. Geological Survey, were obtained. On these maps, marshes, swamps, slow-moving streams, ponds and other large water bodies, which, according to the terrain, appeared to be suitable for mosquito breeding, were selected as collection points. 2. In certain portions of the Commonwealth, the Massachusetts Reclamation Board and its many affiliates were carrying out mosquito control projects. Members of the Reclamation Board were able to spot on these Geological Survey maps, places where they knew mosquitoes were breeding. Thus, by two methods, we were able to select between ten and twenty collection points in almost every town in the Commonwealth. This made a total of from 3510 to 7020 collection points for the 351 towns and cities.

At the completion of the training course, about the middle of June, the foremen returned to their districts and began the training of their personnel. During the second week of training, many of the collection points selected by us were visited by the crews and surveyed. Thereafter, new collection points were selected by actual field experience. For example: If a crew member found a good mosquito breeding place which was likely to remain permanent throughout the season, he made out a survey sheet for that point, relaying the information to his foreman, who in turn, passed it on to the area supervisor. The area supervisor, in the weekly conference at the Boston headquarters, submitted the new collection point to the technical director and the entomological staff, who decided, on the basis of the accompanying specimens and survey sheet, whether or not the collection point was desirable. If so, it was approved.

At the beginning of the Survey, each crew was supplied with a duplicate set of maps of the towns in its district. These were maps which were compiled by the Massachusetts Geodetic Survey in 1936. They were printed on $8\frac{1}{2}$ x 11 inch paper and fitted easily into the crew members' carrying kits. On each map were spotted the collection points as selected

before the field work started. New points were spotted as they were made. Area supervisors were furnished with a book of these maps to which they transcribed all the approved collection points in their area. The area supervisors' map books were brought to the central office from time to time where the approved collection points were transcribed into a master map book of the entire state.

In order to obtain detailed information concerning each collection point, a Survey of Collection Point Form was devised. It may be pertinent to mention at this point that this form and labels which were used by the field workers were approved by the Work Projects Administration as being of such a character as would obtain the desired information with the least possible likelihood of error. It was realized that with lay collectors such as we trained, forms, which were not too complicated, but which contained sufficient material readily adaptable to being transferred to punch cards, had to be developed. Accordingly, we devised a form which was simple to fill in, and contained the information which we desired to use in our punch card analysis. This Survey of Collection Point Form was made out in duplicate. The copy was sent to the Survey headquarters where it was filed. These copies gave us a check on the number of collection points that were being visited regularly in the various towns of the Commonwealth. Therefore, we were able to say in how many places collections were being made at any given time. The original of the survey sheet remained with the crew foreman who was thus able to check the survey and at the same time enabled the continuation of collections at these points whenever a change of personnel occurred. For a detailed description of the Survey of Collection Point Form the reader is referred to the bulletin, "Training Course for Field Personnel".
Survey of Collection Point A Survey of a collection point consisted of the recording of facts and information concerning the conditions existing at the point and its immediate vicinity. The Survey Form contained space for recording observations on the nature of the vegetation, the water, and the terrain, as well as such items as the presence of animals, people, houses, and any other pertinent information. The information required about each collection point was divided into fifteen groups. Each group contained information of one type, and all, together, formed the basis upon which selection of points, as permanent collection points, was made.

The facts obtained from these Survey Forms were used, not only in determining what areas were selected as permanent collection points, but in the tabulation and analysis of the prevalence of mosquitoes in relation to various factors in the environment.

Daily Work of Field Personnel The crew member in each town proceeded on foot along public roads to the designated collection points. During the first visit to a collection point, the crew member made out a survey sheet. He, thereafter, proceeded to collect adult mosquitoes, as described in detail in "Instructions for Catching Adult Mosquitoes". In general, the adults were caught by a net carried by the crew member or by simply placing the killing tube over the resting mosquito for a few minutes until the mosquito was killed. The adults were then placed between layers of cellulose in a pill box. A label was filled out, folded and

placed inside the box.

Larvae were collected by the method described in "Instructions for Collecting Larvae". Water containing the larvae was dipped from puddles, streams, ponds, marshes, etc., with a large dipper. The larvae were then carefully sucked up into a medicine dropper and transferred to a small vial. After the crew member had collected several larvae, he filled the vial to about one inch from the top and added five drops of 40% formalin dyed a light blue for easy identification. The identification slip, marked with the number of the collection point and date of collection, was inserted and the vial corked. A label was filled out, folded, rolled about the vial and secured with a rubber band. If no specimens of either adults or larvae were found, the crew filled in a pink label for the collection point. Upon completion of work at one collection point, the crew member proceeded on foot to the next.

If there were more than one type of water collection in a collection point, a collection of larvae was made in the different kinds of water. Each collection was placed in a separate vial and separately labelled. For example, a pond, a running stream and a tree-hole were three different types of water. Collections were made from all three, the specimens being placed in three separate vials, each with its own label.

Three different types of labels were used: (1) Label for Regular Collections, white; (2) Label for Regular Collections, pink; and (3) Label for Occasional Collections. All three labels were used by the field collectors and are discussed in the bulletin "Training Course for Field Personnel". The white label for Regular Collections was used for those made at permanent collection points. The pink label was used for permanent collection points but was filled out only when no specimens were found. It was used only by the W. P. A. personnel and it was intended as a check on the individuals. The label for occasional collections was used for specimens which were picked up at places other than regular collection points. Most of the volunteer collections were of this type; and, consequently, this label was the one most frequently used by the volunteers. As in the case of the survey sheet, the labels contained several lists from which the collector selected the appropriate items. The direction of the wind was easily established as the collector possessed a map of the town. Only the cardinal points of the compass, with but one subdivision, were used in the description of wind direction. Complete instructions for the use of the different labels were supplied each collector.

During the first two weeks of the Survey, while the field personnel was being trained, collections were small in number. Collections were started on a state-wide basis during the first week of July. Toward the end of July the crews were familiar with their districts and collection points were established in most of the towns. By the end of July, with few exceptions, collections were being made from most of the towns in the Commonwealth. Thereafter, the number of collections continued to increase and reached a maximum late in September. The months of May, June and July were exceptionally dry. The normal rainfall for these months is 10.25 inches. In 1939 there fell only 6.53

inches of rain, or about two-thirds of the normal. Many marshes, small ponds and streams dried up, others decreased in size, and puddles and small collections of water were practically non-existent.

This lack of rainfall was reflected in a diminution in the number of mosquitoes. Where, in 1938, mosquitoes were unusually prevalent, due to the heavy rainfall throughout the summer and early autumn, in 1939 mosquitoes were comparatively scarce. Although there are no established data on the prevalence of mosquitoes in 1938, the observations of mosquito control men may be taken as authentic evidence. These workers, as well as the residents, observed that during 1938 mosquitoes were unusually prevalent throughout southern Massachusetts. In 1939, on the other hand, mosquitoes were so scarce that vacationists reported they were able to sleep in the open without screens or netting. This luxury of sleeping under the stars without fear of mosquitoes, was a blessing which had not been given for many years.

Collections of mosquitoes were, therefore, quite difficult during July. As many ponds, marshes and streams dried up, new collection points had to be established. Fortunately, in August, rainfall was slightly above normal. This increased rainfall was reflected in the increased prevalence of mosquitoes. The number of collections in August increased and in September reached a maximum. However, there was not enough rain to compensate for the three preceding dry months and water collections began to decrease again in size and number. At no time during the summer and autumn of 1939 was there a normal predominance of mosquitoes. It is our distinct impression and that of many of the mosquito control men, that mosquitoes throughout 1939 were unusually scarce.

There is one exception to this observation from Cape Cod where, during 1938, there were many heavy rains in this region. Ponds filled up, and in the spring of 1939 were at an unusually high level, in some instances higher than any recorded in the past twenty-five years. In this region, Mansonia perturbans, a vicious biter, was unusually prevalent, especially in the spring and early summer.

The number of collections in the different districts varied greatly. The apparent non-existence of certain species in certain districts may be accounted for by the difficulty of obtaining qualified personnel in these areas. Other factors which influenced collecting were the size of the area to be covered, the nature of the terrain and the meteorological conditions. An attempt to evaluate the completeness of collections and the influence of these various factors is made in the analysis of the data.

CHAPTER VII

TECHNICAL PROCEDURES

IDENTIFICATION OF SPECIMENS The identification of collections was carried out by the entomological staff consisting of a consultant entomologist, a chief entomologist, four senior entomologists, four junior entomologists and several laboratory assistants. The consultant entomologist did not do routine identification, but examined specimens which were unusual or difficult to identify. Those which were thought to be new species, insofar as their collection in the Commonwealth was concerned, were sent to the United States Department of Agriculture entomologists in Washington. In this way, all unusual specimens of species which were collected for the first time in the Commonwealth were identified not only by the consultant entomologist, but also by the federal entomologists.

The chief entomologist was directly in charge of the identification. He was responsible for the assignment of work to the various entomologists. Like the consultant, he did not do routine identification except when there was an accumulation of specimens. His first function was the direction of the identification work and examination of unusual specimens. The routine identifications were done by the senior and junior entomologists. Most of the identification of adults was performed by the senior entomologists whereas the larvae which were more easily recognized were identified by all the workers.

It is estimated that the rate of identification was fifty collections per man per day for adults, and one hundred twenty per man per day for larvae. These estimates are based upon a man working alone and in conjunction with such other tasks as were assigned to him. When a laboratory assistant aided the entomologist, the number of specimens which could be identified in the course of a day was more than doubled. This was especially true when the men became experienced in the handling of specimens. Towards the end of the Survey, as many as one hundred fifty collections of adults, and two hundred fifty to three hundred collections of larvae were examined by a single man.

Because of the Survey's interest in obtaining data on the distribution and prevalence of all species of mosquitoes,it was necessary to identify every specimen which reached the laboratory. The specimens arrived once a week, on Fridays, when the Area Supervisors came to Boston to attend weekly conferences. The specimens from each district were kept in separate containers. This facilitated the identification as most of the collections coming from the same district were of the same general character, that is the same species predominated.

The adult specimens reached the laboratory between layers of cellotex, in small pill boxes. The label accompanying each, had been inserted between the drawer and the casing of the pill box. On opening the box the label was removed and unfolded. The identification data on the specimens was written on the reverse side of the label. The labels

from each district for each week were kept in one bundle and shipped to the filing room. Similarly, labels around the vials containing the larvae were unrolled and the identification data noted on the reverse side. These labels were handled in the same way as those for the adult collections.

The identification data recorded on each label consisted of the names of the genus and species, the letters "A" and "L" for adults and larvae respectively, the number of specimens of each and the name of the person who made the identification. If the specimens were unidentifiable, either because of deterioration or lack of maturity, a note to this effect was made. If the specimen were not a mosquito, the letters "NM" were placed on the bank of the label. In this way it was possible to use but one form, containing both the collector's and the identifying data. The transcription of this information on summary sheets was much less complicated than it would have been, had two forms been used. In addition, in case of any doubt as to identification data, it was possible to check back and ascertain who had made the identification.

IDENTIFICATION KEY The technique of mosquito identification consists mainly of a process of elimination. The identification key for adults and larvae notes certain characteristics as either present or absent. The presence or absence of a particular characteristic determines whether the mosquito is further identified in one group or another. This same method is followed through until the absence or presence of a single characteristic determines the species of the mosquito.

At the beginning of the Survey, identifications were based upon Tulloch's key which was published in 1930. When about one hundred thousand specimens had been identified, enough data was collected to revise this key, and, as one of the objectives of the Survey, a new key was compiled and published. This new identification key was used throughout the remainder of the Survey. It is adaptable to use in New England and perhaps in New York as well.

Special Mosquito Collections In addition to the routine identification of specimens and the revision of the identification key, the entomologists had several other duties. Special collections of unusual specimens especially those found for the first time in the state, were made by the entomologists. Whenever a W. P. A. collector found an unusual specimen he was asked to revisit the location of the collection point for additional specimens. At the same time an entomologist was sent to this area to make further collections at the same place and in the surrounding area, in an attempt to obtain large numbers of specimens.

The entomologists attempted to collect mosquitoes naturally infected with equine encephalomyelitis. These attempts were made whenever a case of this disease was reported to us by the State Department of Agriculture. Light and animal baited traps were taken to the place from which the case had been reported. However, the disease was so rare that cases were not reported until the afflicted horse had died.

Consequently, we arrived at the farm or stable where the animal had been quartered too late to collect the mosquitoes whose bite was responsible for the infection. This lapse of time was one of the reasons why our collections were a failure. The majority of these cases were reported to us late in the mosquito season and we were unfortunate enough to have meteorological conditions which were unfavorable to mosquitoes. As a matter of fact, very few specimens were collected by use of animal-baited and light traps on these occasions, and, therefore, we could not expect to collect naturally infected mosquitoes. In conclusion, these endeavors to collect the mosquito vector which had been infected naturally with equine encephalomyelitis could not be considered a fair trial because of the lapse of time which had occurred between the onset of the disease and the arrival of the entomologists, and because of the small number of mosquitoes which were collected during these endeavors.

Additional light trap collections were made from time to time in several parts of the state. These collections which were made principally at the earlier part of the season were quite satisfactory and on one such collection over one thousand individual specimens were obtained in the course of an evening. However, when there were unfavorable meteorological conditions such as a fresh wind or a drop in temperature, collections were poor.

The entomologists assisted in the supervision of the methods of collection used by the W. P. A. personnel. Periodical trips were made to the various districts in an attempt to check on the methods which were being used in the field by the individual workers and to instruct and assist them in improving their technique. This staff likewise assisted in the checking of the surveys of collection points, and were sent out on special check trips whenever we had cause to suspect that specimens were not authentic.

Several permanent collections of adults and larvae were made. These were intended as a permanent record of the collections made by the Survey and some were sent to various institutions which had requested such collections. Hypopygial mounts were made of many of the species. All these collections are available for future use in the identification of specimens and serve as a sure check on any work which may be carried out in the future.

In all, the entomologists examined and identified forty nine thousand collections, consisting of two hundred seventy eight thousand specimens. This figure includes the collections made by volunteers. It is our opinion that the entomological staff of a survey of this type should be quite large because its functions are so varied and important to the success of the survey as a whole. When organizing new surveys it is our recommendation that allowances be made for a greater number of entomologists.

CHAPTER VIII

ANALYSIS OF DATA

Posting Sheets   In order to facilitate the posting of the data, we devised a summary sheet, which could be used for the original recording of the data and for the final summarizing. On this sheet there were spaces for all the items on both sides of the label. The names of the mosquitoes were arranged alphabetically by genus and species. All the mosquitoes that were known to occur in Massachusetts were included and room was left for such mosquitoes as might be found for the first time in Massachusetts during the course of the Survey. The information from the front of the label was entered on this sheet according to the attached code. The identification data on the opposite side of the label was entered in two ways, by number of specimens of each species, Adult or Larva, and by the number of collections of each species.

The labels were filed aphabetically by counties and towns, numerically by collection point numbers and thereafter chronologically by weeks. Each label was entered in this order upon the sheets as a separate entry. There was one summary sheet for each collection point. As collections were made at a given collection point on the average of once a week, there was one entry per week for each collection point on this sheet. If there were more than one entry, these were added every week and the sum written in red on the following line. The weekly totals from the collection point summary sheet were transferred to a town sheet of which there was one for each city or town in the Commonwealth. These entries in turn were added every week and transferred to a town summary sheet. In this way a running summary of the total findings in a town for the season could be obtained from a single record sheet. Occasional collections were entered on the town summary sheet and added to the collection point totals. In this way, the town summaries included all the collections made in the town.

A separate account was kept for the W. P. A. collections and the volunteer collections. The two groups were finally combined on a new sheet entitled "Combined Summary of Town". This sheet contained the final summary of the project collections of mosquitoes in the town. At the end of the season, the combined town summaries were added and this accumulative result was the total collections of mosquitoes made in that town during the season. These accumulative results were transferred to county summary sheets where the totals for the counties were determined. Similarly, the counties were totaled on a state sheet which was the total number of mosquitoes and the total number of collections for the Commonwealth throughout the season.

Punch Card Analysis   In order to analyze this large number of collections, it was necessary to resort to the Remington Rand Punch Card Method. A ninety column punch card with ten items to a column was used. Two sets of cards were employed for the analysis of data and therefore two separate codes were used as these sets were entirely independent of each other. Both codes are attached. The Town Code and the Collection Point Code are different except for the method of recording the collections of the various species.

MOSQUITO SURVEY

DEPARTMENT OF PUBLIC HEALTH

CODE FOR SUMMARY SHEET

NO. OF COLLECTION POINT

Example: 030712
03 indicates Barnstable County
07 " Town of Falmouth
12 " Number of Collection Point as noted on map.

WEEK OF YEAR
NO. OF MONTH
DAY IN MONTH
HOUR
A.M. OR P.M.

CONDITION OF AREA:
0 - No Observation
1 - Very dry
2 - Dry
3 - Moist
4 - Wet
5 - Submerged

VEGETATION:
0 - No Observation
1 - Dead
2 - Withered
3 - Drying
4 - Healthy
5 - Succulent

WEATHER:
0 - No Observation
1 - Sunny
2 - Cloudy
3 - Foggy
4 - Misting
5 - Raining

WIND:
0 - No Observation
1 - None
2 - Mild
3 - Moderate
4 - Strong

DIRECTION OF WIND:
0 - No Observation
1 - N
2 - N E
3 - E
4 - S E
5 - S
6 - S W
7 - W
8 - N W

PREVALENCE OF ADULTS:
0 - No Observation
1 - None
2 - 1 to 5
3 - 6 to 25
4 - Scores
5 - Hundreds
6 - Thousands
7 - Hundreds of Thousands

PREVALENCE OF LARVAE:
0 - No Observation
1 - None
2 - 1 to 5
3 - 6 to 25
4 - Scores
5 - Hundreds
6 - Thousands
7 - Hundreds of Thousands

SPECIMENS COLLECTED FROM

WATER COLLECTIONS

NATURAL 00 - 25

04 Ditch
08 Fresh Swamp
10 Pond
11 Puddle
12 Quarry
15 Salt Marsh
16 Stream
17 Stump Hole
19 Tidal Flat

ARTIFICIAL 26 - 50

26 Barrel
27 Bird Bath
28 Bucket
30 Cistern
32 Dish
33 Fountain
35 Flower-pot container
40 Roof Gutter
45 Tin Can
46 Troughs
48 Watering Pot

OUTDOORS 51-75

58 Dump
60 Field
62 Lakeside
63 Meadow
64 Marsh
65 Riverside
66 Road
67 Seashore
68 Shrubs
69 Trees
73 Weeds
74 Woods
75 Yard

BUILDINGS 76 - 100

78 Barn
80 Chicken Coop (Hen House)
82 House
85 Other Outhouse
86 Stable
90 Cattle
91 Horses
92 Mules
93 Sheep
99 Man

Recording by Genera, Species
Enter actual number under each

A - Adults
L - Larvae

Under unclassifiable enter - actual number
Other species - insert name of species and enter actual number, after consultation with Technical Director.

REMARKS

CHANGES 00 - 25

02 Burned over
05 Construction
10 Dam opened
11 Dam closed
12 Drained
15 Harvested
20 Oiled
21 Other Mos. Control Measures
22 Pastured
23 Plowed
24 Timber cut

ANIMALS 26 - 50

27 Chicken
28 Cattle
29 Dogs
30 Domestic Ducks
31 Grouse
32 Hogs
33 Horses
34 Mules
35 Partridges
36 Pheasants
37 Pigeons
39 Sheep
45 Wild Ducks

HUMANS 51 - 75

53 Bathers
55 Campers
60 Farmers
61 Fisherman
64 Harvesters
70 Picnickers

COLLECTION POINT CODE

Column

1 & 2) COUNTY NUMBER — Counties are numbered from 1 to 14 as follows:

3) Barnstable	2) Dukes	12) Hampshire	6) Norfolk
14) Berkshire	8) Essex	9) Middlesex	4) Plymouth
5) Bristol	11) Franklin	1) Nantucket	7) Suffolk
	13) Hampden		10) Worcester

3 & 4) TOWN NUMBER — The towns are numbered alphabetically in each county, beginning with 1.

5 & 6) WEEK OF YEAR — The weeks are numbered chronologically beginning with the first week of the year.

7 & 8) NUMBER OF DRAINAGE AREA

Salt Water
11) Cape Cod
12) Center Coast
13) East Coast
14) Ipswich
15) Islands
16) South Coast

Merrimac
31) Assabet
32) Concord
33) Merrimac
34) Nashua
35) Sudbury

Connecticut
51) Chicopee
52) Connecticut
53) Deerfield
54) Farmington
55) Millers
56) Westfield

Boston Harbor
21) Charles
22) Mystic
23) Neponset

Rhode Island
41) Blackstone
42) French
43) Taunton
44) Ten Mile
45) Quinebaug

Berkshires
61) Hoosic
62) Housatonic

9) Contour
0) Not marked
1) Level
2) Valley
3) Hillside
4) Hilltop
5) 1 & 2
6) 1 & 4
7) 2 & 3
8) 3 & 4
9) Other

10) Nature of Terrain
0) None
1) Not marked
2) Cultivated fields
3) Meadow pastured
4) Meadow unpastured
5) Rocky
6) Woods
7) Meadow & woods
8) Meadows & cul. fields
9) Other

11) Natural Water Colls.
0) None
1) Not marked
2) Marsh & swamp
3) Pond or Lake
4) Puddle
5) River or Stream
6) Rocky crevice
7) Run. & Still Water
8) Tidal Flat
9) Other

12) Artificial Coll.
0) None
1) Not marked
2) Cranberry bog
3) Excavation
4) Quarry
5) Sand pit
6) Root Hole
7) Tree Hole
8) Well
9) Other

13) Water Containers
0) None
1) Not marked
2) Artificial pool (pond)
3) Barrels
4) Birdbath or flower pot
5) Cesspools & overflow
6) Cistern (open)
7) Dump
8) Water trough
9) Other

14) Vegetation at Water Edge
0) None
1) Not marked
2) Cat-tails & reeds
3) Pickerel weeds
4) Arrow heads
5) Bulrush
6) Marsh grass
7) Cat-tails, reeds & other
8) Marsh grass & other
9) Other

COLLECTION POINT CODE

Column

15) Vegetation in Water
- 0) None
- 1) Not marked
- 2) Lily pads
- 3) Algae
- 4) Duckweeds
- 5) Water mosses
- 6) 2 & Other
- 7) 3 & Other
- 8) 4 & Other
- 9) Other

16) Character of Water
- 0) None
- 1) Not marked
- 2) Brown
- 3) Colorless
- 4) Muddy
- 5) Floatage
- 6) 5 & 2
- 7) 5 & 3
- 8) 5 & 4
- 9) Other

17) Character of Bottom
- 0) None
- 1) Not marked
- 2) Earth or Mud
- 3) Leaves
- 4) Rock
- 5) Sand
- 6) 2 & 4
- 7) Vegetation
- 8) 3 & Other
- 9) Other

18) Trees
- 0) None
- 1) Not marked
- 2) Evergreen
- 3) Hardwood
- 4) Willows
- 5) Fallen trees
- 6) Burned trees
- 7) 2 & 3
- 8) 5 & 2 or 3
- 9) Other

19) Weeds & Underbrush
- 0) None
- 1) Not marked
- 2) Bushes
- 3) Hedges
- 4) Weeds over 3 feet
- 5) Weeds under 3 feet
- 6) 4 & 5
- 7) 2 & 5
- 8) 2 & weeds any kind
- 9) Other

20) Animals in Area

21) 00) None
- 01) Not marked

Susceptible Birds
- 10) 15 & 16
- 11) Horses
- 12) Mules
- 13) Horses & Mules
- 14) Horses & Mules & Susceptible Birds
- 15) Horses & Non-Susceptible Birds
- 16) Horses & Non-Susceptible Mammals
- 17) 14 & 15
- 18) 14 & 16
- 19) 14, 15 and 16

Susceptible Birds
- 20) All 20's, 30's & 40's
- 21) Young Chickens
- 22) Pheasants
- 23) Pigeons
- 24) Cowbirds
- 25) Red wing.Blackbird
- 26) Sparrows
- 27) Several Susceptible
- 28) Susceptible & Non-Susceptible Birds
- 29) Susceptible Birds & Non-Susceptible Animals

Non-Susceptible Birds
- 40)
- 41) Chickens
- 42) Domestic Ducks
- 43) Gulls
- 44) Wild Ducks
- 45) Turkey
- 46) Several
- 47) Other
- 48)
- 49)

22) Buildings in Area
- 0) None
- 1) Not marked
- 2) Less than 5
- 3) 6 - 25
- 4) 26-100
- 5) More than 100 or factories
- 6) Stables & others
- 7) Poultry houses
- 8) Stables

23) Mosquito Control Measures
- 0) None
- 1) Not marked
- 2) Diking
- 3) Ditching
- 4) Filling
- 5) Oiling
- 6) 2 & 5
- 7) 3 & 5
- 8) 4 & 5
- 9) Other

24) Prevalence of Mosquitoes
- 0) None
- 1) Not marked
- 2) A.scarce & no L.
- 3) A.numerous & no L.
- 4) L.scarce & no A
- 5) L.numerous & no A.
- 6) A.scarce & L.scarce
- 7) A.scarce & L.numerous
- 8) A.numerous & L.scarce
- 9) A.numerous & L.numerous

Non-Susceptible Mammals
- 30) Small rodents
- 31) Cats
- 32) Cattle
- 33) Dogs
- 34) Hogs
- 35) Rodents
- 36) Sheep
- 37) Several
- 38) Other
- 39) Any 30 & Any 40

COLLECTION POINT AND TOWN CODE

Columns 25-55 & 57-80, also 85-90, use this system:

1) 1 collection
2) 2-5 collections
3) 6-10 collections
4) 11-15 collections
5) 16-20 collections
6) 21-30 collections
7) 31-50 collections
8) 51-100 collections
9) Over 100 collections

25)	Aedes atropalpus	A
26)	Aedes atropalpus	L
27)	Aedes aurifer	A
28)	Aedes canadensis	A
29)	Aedes canadensis	L
30)	Aedes cantator	A
31)	Aedes cantator	L
32)	Aedes cinereus	A
33)	Aedes cinereus	L
34)	Aedes dorsalis	A
35)	Aedes dorsalis	L
36)	Aedes excrucians	A
37)	Aedes excrucians	L
38)	Aedes fitchii	A
39)	Aedes fitchii	L
40)	Aedes hirsuteron	A
41)	Aedes hirsuteron	L
42)	Aedes intrudens	A
43)	Aedes intrudens	L
44)	Aedes sollicitans	A
45)	Aedes sollicitans	L
46)	Aedes stimulans	A
47)	Aedes stimulans	L
48)	Aedes taeniorhynchus	A
49)	Aedes taeniorhynchus	L
50)	Aedes triseriatus	A
51)	Aedes triseriatus	L
52)	Aedes vexans	A
53)	Aedes vexans	L
54)	Aedes implacabilis	A
55)	Aedes implacabilis	L

56) Vectors
- 5) Not present
- 1) Present

  Names of Vectors
  - Aedes atropalpus
  - Aedes cantator
  - Aedes sollicitans
  - Aedes triseriatus
  - Aedes vexans

57)	Anoph.maculipennis	A
58)	Anoph.maculipennis	L
59)	Anoph.punctipennis	A
60)	Anoph.punctipennis	L
61)	Anoph.quadrimaculatus	A
62)	Anoph.quadrimaculatus	L
63)	Anoph.walkeri	A
64)	Anoph.walkeri	L
65)	Culex apicalis	A
66)	Culex apicalis	L
67)	Culex pipiens	A
68)	Culex pipiens	L
69)	Culex salinarius	A
70)	Culex salinarius	L
71)	Culex territans	A
72)	Culex territans	L
73)	Mansonia perturbans	A
74)	Mansonia perturbans	L
75)	Theobaldia melanurus	A
76)	Theobaldia melanurus	L
77)	Theobaldia morsitans	A
78)	Theobaldia morsitans	L
79)	Uranotaenia sapphirina	A
80)	Uranotaenia sapphirina	L

81) Others
- 1) Aedes trichurus A
- 2) Aedes trichurus L
- 3) Aedes trivittatus A-L-7
- 4) Anoph.crucians L
- 5) Aedes punctor A
- 6) Aedes punctor L

82) Others
- 1) Psorophora ciliata A
- 2) Psorophora ciliata L
- 3) Psorophora columbiae L

83) Others
- 1) Orthopodomyia L
- 2) Theobaldia impatiens A
- 3) Theobaldia inornata A
- 4) Wyeomia smithii L

84) Others
- 1) Chaoborus
- 2) Corethrella
- 3) Eucorethra
- 4) Mochlonyx
- 5) Dixa
- 6) Chaoborus & Dixa
- 7) Chaoborus Mochlonyx

85)	Aedes unidentified	A
86)	Aedes unidentified	L
87)	Anoph.unidentified	A
88)	Anoph.unidentified	L
89)	Culex unidentified	A
90)	Culex unidentified	L

TOWN CODE

Column

2) COUNTY NUMBER — Counties are numbered from 1 to 14, the counties are numbered as follows:

3) Barnstable	11) Franklin	6) Norfolk
14) Berkshire	12) Hampshire	4) Plymouth
5) Bristol	13) Hampden	7) Suffolk
2) Dukes	9) Middlesex	10) Worcester
8) Essex	1) Nantucket	

4) TOWN NUMBER — The towns are numbered alphabetically in each county beginning with 1.

5)
6) WEEK OF YEAR — The weeks are numbered chronologically beginning with the first week of the year.

7) NUMBER OF DRAINAGE AREA
8) The drainage areas are numbered as follows:

Salt Water	Merrimac	Connecticut
11) Cape Cod	31) Assabet	51) Chicopee
12) Central Coastal	32) Concord	52) Connecticut
13) East Coastal	33) Merrimac	53) Deerfield
14) Ipswich	34) Nashua	54) Farmington
15) Islands	35) Sudbury	55) Millers
16) South Coastal		56) Westfield

Boston Harbor	Rhode Island	Berkshires
21) Charles	41) Blackstone	61) Hoosic
22) Mystic	42) French	62) Housatonic
23) Neponset	43) Taunton	
	44) Ten Mile	
	45) Quinebaug	

9)
10) Deviation of 1939 Precipitation From Average

9	10
5)	0) Zero
1)	1) Under 5.1
()0	2) 5.1-10.0
	3) 10.1-15.0
	4) 15.1-25.0
	5) 25.1-40.0
	6) 40.1-55.0
	7) 55.1-70.0
	8) 70.1-100.0
	9) Over 100

11)
12) Deviation of 1939 Precipitation From 1938

11	12
5)	0) Zero
1)	1) Under 10.1
9)0	2) 10.1-25.0
	3) 25.1-40.0
	4) 40.1-55.0
	5) 55.1-70.0
	6) 70.1-85.0
	7) 85.1-100.0
	8) 100.1-200
	9) Over 200

TOWN CODE

13) Deviation of 1939
14) Temp. From Ave. Temp.

13	14
5)	0) Zero
1)	1) Zero- 0.50
9)0	2) 0.51- 1.00
	3) 1.01- 1.50
	4) 1.51- 2.00
	5) 2.01- 3.00
	6) 3.01- 5.00
	7) 5.01- 7.50
	8) 7.51-10.00
	9) Over-10.

19) Total Number of Larval Collection

1) 1
2) 2 - 5
3) 6 - 10
4) 11- 15
5) 16- 20
6) 21- 30
7) 31- 50
8) 51- 100
9) Over100

23) % W.P.A. Larvae

1) Zero - 5
2) 6 - 10
3) 11 - 15
4) 16 - 20
5) 21 - 30
6) 31 - 40
7) 41 - 50
8) 51 - 75
9) 76 - 100

15) Deviation of 1939
16) Temp. From 1938 Temp.

15	16
5)	0) Zero
1)	1) Under 0.51
9)0	2) 0.51- 1.00
	3) 1.01- 2.00
	4) 2.01- 5.00
	5) 5.01- 7.50
	6) 7.51-10.00
	7) 10.01-12.50
	8) 12.51-15.00
	9) Over-15

20) Total Number of Adult Specimens

1) 1
2) 2 - 5
3) 6 - 10
4) 11- 20
5) 21- 30
6) 31- 50
7) 51- 100
8) 101- 200
9) Over 200

24) Number of Coll. Points

1) 1
2) 2
3) 3 - 5
4) 6 - 8
5) 9 - 11
6) 12- 18
7) 19- 31
8) 32- 48
9) Over48

17) Direction of Prevailing winds

0) None
1) Not marked
2) N
3) NE
4) E
5) SE
6) S
7) SW
8) W
9) NW

21) Total Number of Larval Specimens

1) 1
2) 2 - 5
3) 6 - 10
4) 11- 20
5) 21- 50
6) 51- 100
7) 101- 150
8) 151- 200
9) Over 200

18) Total Number of Adult Collections

1) 1
2) 2 - 5
3) 6 - 10
4) 11- 15
5) 16- 20
6) 21- 30
7) 31- 50
8) 51- 100
9) Over100

22) % W.P.A. Adults

1) Zero - 5
2) 6 - 10
3) 11 - 15
4) 16 - 20
5) 21 - 30
6) 31 - 40
7) 41 - 50
8) 51 - 75
9) 75 - 100

Columns 25 to 90 are the same in this code as in the Collection Point Code. See Page 43

Town Code The weekly summaries of collections in every town included both W. P. A. and volunteer collections and were coded according to the accompanying code and then punched on a set of cards. The code enabled an analysis of the geographical distribution of the various species, the relation of meteorological conditions to the distribution of the species, the geographical distribution of the vectors of the disease, and the distribution of mosquitoes according to rivers and drainage areas. This code covered all collections made during the course of the Survey. As a card was punched for every week during which collections were made, this set of cards enabled us to determine the seasonal distribution and prevalence of the various species. An attempt has been made to do this on a quantitative as well as a qualitative basis.

Collection Point Code The collection point code was applied to the data obtained from two sources: (1) Survey of regular collection points. (2) Seasonal summaries for collections made at the collection points. The code enabled the compilation of information concerning the influence of environmental factors upon the geographical distribution and prevalence of mosquitoes. This code made possible the correlation of various environmental factors which characterized the breeding places of certain species of mosquitoes. It was likewise possible to determine the distribution of mosquitoes according to counties and watershed areas.

In order to prevent mistakes between the code sheets and the punch cards of the two separate analyses, the town code analysis was made with white code sheets and two sets of cards, one pink and the other white. The collection point code analysis was made with yellow code sheets and the two sets of cards, blue and green. It was necessary to have these duplicate sets of punch cards as the establishment of the various correlations required more sorting than one set of cards could stand.

Checking As in all statistical analyses of this type, the avoidance of errors was paramount throughout the analysis of the data. Therefore, the posting, the coding and the punching was checked and re-checked in order to obviate as many mistakes as possible. When the posting was first begun, a check revealed approximately a ten percent error. With experience this was reduced to five. A spot re-check of the posting revealed less than one half of one percent error. In coding, the initial error was smaller, amounting to about three percent. On a spot re-check, this was found to be about one in six thousand. The punch cards themselves were checked against the code sheets by the use of a Remington Rand Interpolator which printed the numbers punched on the cards themselves. These in turn were checked with the code sheet. We found on an initial check an error of approximately two percent. On a spot re-check this error was reduced to about one half of one percent and very few errors were found during the sorting of the cards.

The time required for the coding of both sets was about four weeks. The punching and checking of the cards required about five weeks, exclusive of the time required in the servicing of the machines. The sorting of the cards was completed in six weeks.

CHAPTER IX

SAMPLING THE MOSQUITO POPULATION

In a survey of this type, only a relatively small sample of the entire mosquito population can be studied. Therefore, in order to be in a position to generalize about the whole, the sample has to be representative of the population. In this Survey, the selection of samples has been carefully avoided. The collection of specimens was made in such a way as to insure true random sampling without relation to any factors except two. The first factor was the limitation of the area in which a collector was to obtain his samples. The town or city was arbitrarily picked as the most practical basic area unit. The other factor influencing the collection was the limitation of the number of specimens of larvae to ten per sample. This number was chosen as the practical limit which could be identified by the entomological staff. Moreover, it was felt that in ten specimens from any one place, there would be ample opportunity for true sampling of the species existing in that place. Although efforts were made to obtain specimens from the same breeding places at regular intervals throughout the year, all places where mosquitoes were found breeding were sampled. Moreover, only one sample was submitted from each breeding place. Under these conditions, the mosquitoes represent a true random sample of the mosquito population.

Duration of State-Wide Survey The Survey's training course for the W. P. A. supervisors, foremen and assistant foremen was completed on June 23rd. During the following week the W.P.A. crews were assembled, and training of these men was underway. By the first of July most of the crews were operating on a full schedule, and by the middle of July, about one-half of the towns were being covered by the Survey collectors. At the end of July the project was in full swing, and collections were made throughout the state.

The number of towns in which collections were made every week is charted in Figure II. State-wide collections were continued for a period of thirteen weeks throughout the months of August, September and October. Representative collections throughout the state were made during the month preceding this complete state coverage. In this way, the Survey made collections throughout the Commonwealth during the season when equine encephalomyelitis had occurred in 1938. Collections were continued by the Survey through the first week of December, but these were limited to Dukes County, which, because of its geographical situation, has a longer mosquito season.

Mosquito Collections For the purpose of this analysis, a mosquito collection is defined as the finding of either one or more adults or one or more larvae of one species of mosquitoes in one location. If, in a single sample, there are more than one species of larvae, this sample is counted as a separate collection for each of the species represented. By definition, it is impossible to have both adults and larvae in the same collection, as the former are collected from a different location than the latter.

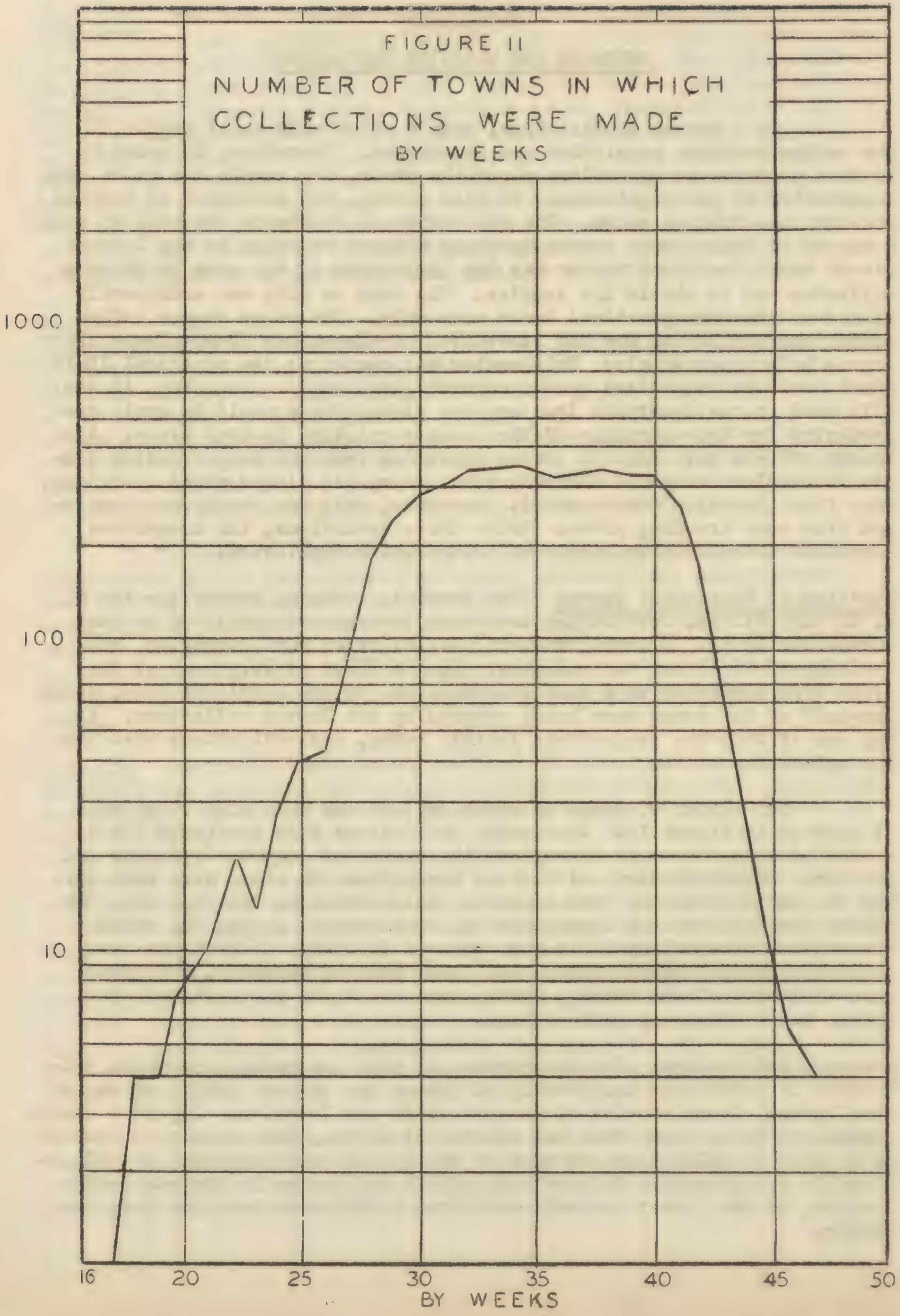


FIGURE II
NUMBER OF TOWNS IN WHICH COLLECTIONS WERE MADE BY WEEKS
1000
100
10
16
20
25
30
35
40
45
50
BY WEEKS

Prior to June 15th, all the collections were made by volunteers, who were enrolled by the Division of Communicable Diseases in the Department of Public Health. By the first of July, the majority of the collections were made by the Survey personnel. Most of the volunteer collections were adults, while those of the Survey personnel were chiefly larvae. The total number of collections is summarized by counties in Table IV. Of the total (49,083) collections of biting mosquitoes 83.5% or 40,983 collections were larvae. The proportion of adults to larvae varied in the various counties. In Barnstable County adult collections were the largest both in number and in percent, representing 33% of the total in that county. In Hampshire County, adult collections comprised only 5% of the total.

The weekly collections are charted in Figure III, this group is plotted on three cycle semi-logarithmic paper. There is an interesting rise in the number of collections made each week, to a peak of 5,399 collections in the 40th week (October 1st to 7th). The following week the crews were limited in travel expenses, and two weeks after the peak the crews were gradually discharged, so that by the 44th week, only one crew was left in the field.

TABLE IV

SUMMARY OF MOSQUITO COLLECTIONS

1939

County	Adults	Larvae	Total
Barnstable	1395	2870	4265
Berkshire	477	4507	4984
Bristol	206	1931	2137
Dukes & Nantucket	625	1563	2188
Essex	989	3711	4700
Franklin	424	2507	2931
Hampden	213	3193	3406
Hampshire	85	1543	1628
Middlesex	1217	6278	7495
Norfolk	464	2514	2978
Plymouth	823	4043	4866
Suffolk	158	388	546
Worcester	1024	5935	6959
TOTAL	8100	40983	49083

The number of collections as determined by punch card analysis is summarized in Table V. The totals for adults and larvae, and the percent distribution of each are given by weeks. The percent distribution of adults is plotted in Figure IV. There was a peak during the 24th and 25th week and a gradual decline thereafter throughout the duration of the Survey. Our interpretation of this peculiar distribution of the adult collections rests on the fact that, subsequent to the 28th week (July 9th to 15th), there was a gradual increase in the number of larvae due to improved breeding conditions, and hence adults grew relatively less numerous as more larvae were collected.

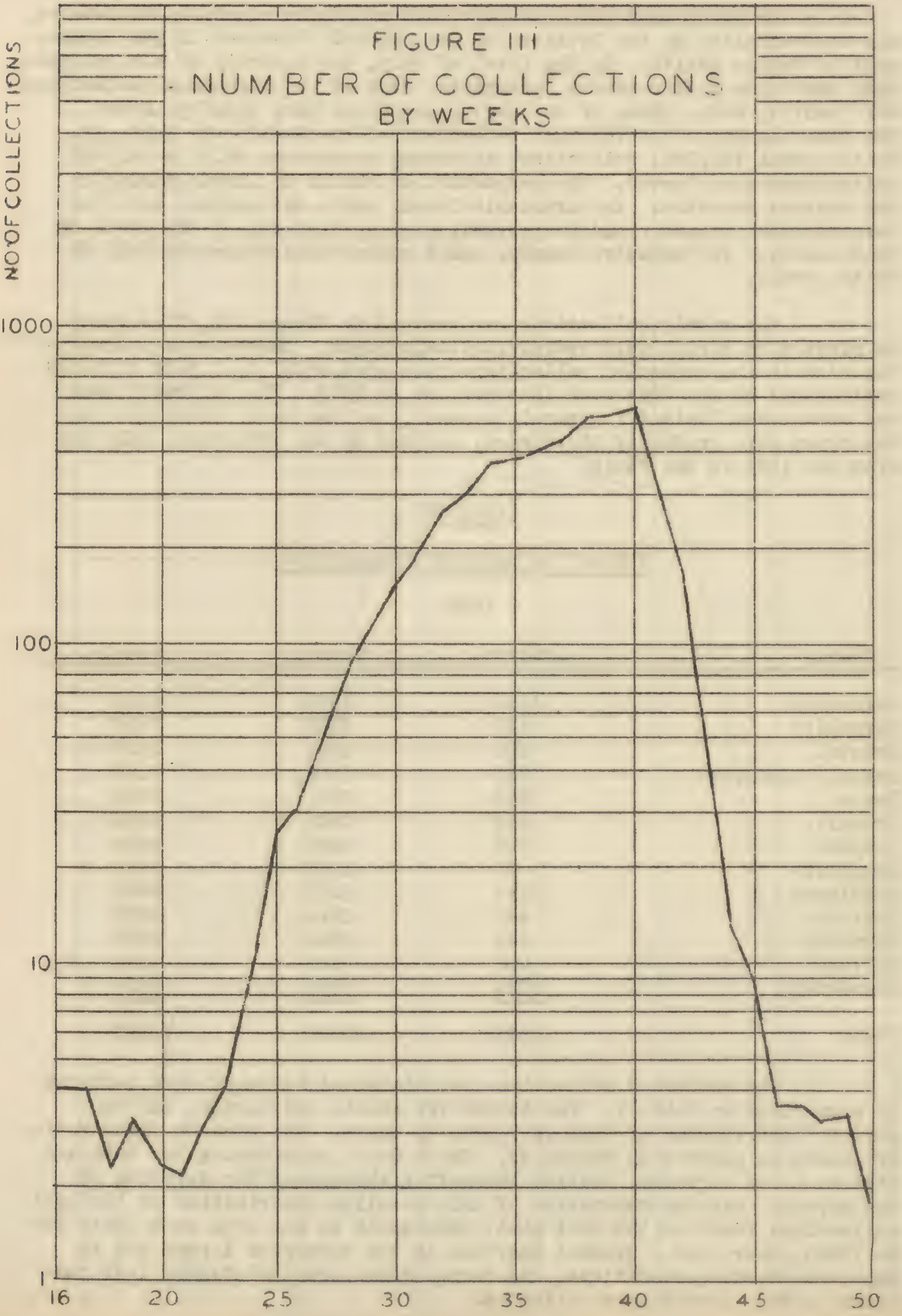


FIGURE III
NUMBER OF COLLECTIONS
BY WEEKS
NO OF COLLECTIONS
1000
100
10
1
16
20
25
30
35
40
45
50

TABLE V

MOSQUITO COLLECTIONS

ADULTS, LARVAE, AND PERCENT DISTRIBUTION

By Weeks

Week of Year	Number of Collections Adults	Larvae	Total	Percent of Distribution Adults	Larvae
16	0	40	40	0	100.0
17	0	40	40	0	100.0
18	1	22	23	4.3	95.7
19	0	32	32	0	100.0
20	1	22	23	4.3	95.7
21	1	20	21	4.8	95.2
22	2	28	30	6.7	93.3
23	11	31	42	26.2	73.8
24	65	31	96	67.7	32.3
25	186	83	269	69.1	30.9
26	191	127	318	60.0	40.0
27	296	249	545	54.3	45.7
28	512	441	953	53.7	46.3
29	394	804	1198	32.9	67.1
30	515	1002	1517	34.0	66.0
31	460	1500	1960	23.5	76.5
32	553	2102	2655	20.8	79.2
33	585	2342	2927	20.0	80.0
34	548	3083	3631	15.1	84.9
35	353	3457	3810	9.3	90.7
36	381	3705	4086	9.3	90.7
37	588	4091	4679	12.6	87.4
38	902	4261	5163	17.5	82.5
39	839	4441	5280	15.9	84.1
40	608	4791	5399	11.3	88.7
41	365	2582	2947	12.4	87.6
42	126	1603	1729	7.3	92.7
43	42	461	503	8.3	91.7
44	0	130	130	0	100.0
45	3	87	90	3.3	96.7
46	1	35	36	2.8	97.2
47	4	32	36	11.1	88.9
48	0	32	32	0	100.0
49	1	32	33	3.0	97.0
50	0	17	17	0	100.0
	8534	41756	50290*	17.0	83.0

* These figures were obtained from the punch card analysis by interpolation from serial grouping. The actual total was 49,083.

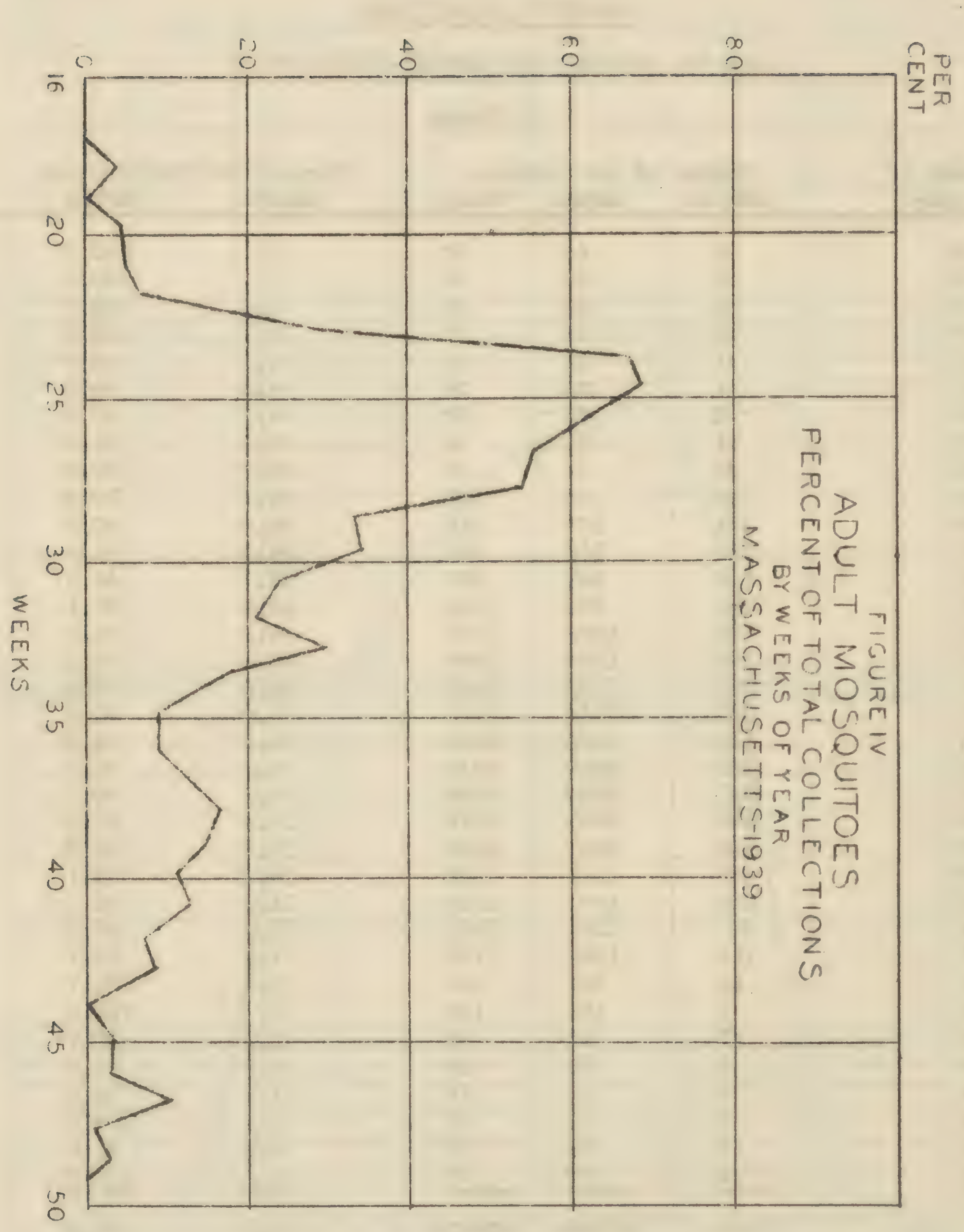
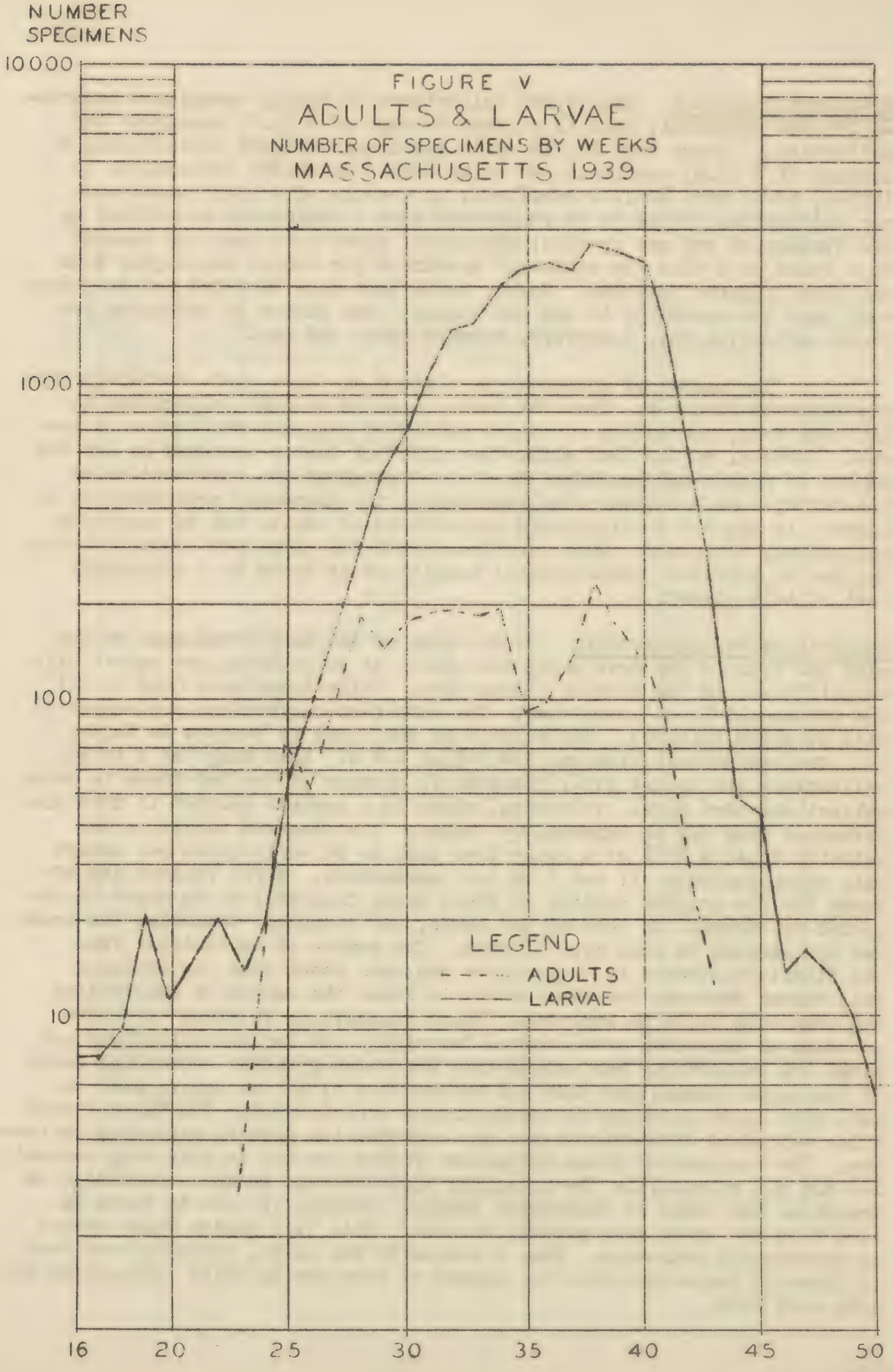


FIGURE IV
ADULT MOSQUITOES
PERCENT OF TOTAL COLLECTIONS
BY WEEKS OF YEAR
MASSACHUSETTS-1939
PER CENT
0
20
40
60
80
16
20
25
30
35
40
45
50
WEEKS

Specimens Collected The 49,083 collections of biting mosquitoes comprised 278,555 specimens; this is a gross average of 6 (5.7) specimens per collection. There were 23,719 adult specimens in 8,100 collections, an average of 3 (2.9) specimens per collection. In 40,983 collections of larvae, there were 254,759 specimens, an average of 6 (6.2) specimens per collection. It is to be remembered that a collection is defined as the finding of any one species; therefore, since more than one species were found at a time the number of specimens per sample was higher than the above figures indicate. Survey collectors were directed not to gather more than ten specimens in any one sample. The number of specimens per field collection was, therefore, between seven and ten.

The number of specimens is plotted on three cycle semi-logarithmic paper in Figure V. When the Survey started to make collections in the 24th week, the number of adults collected exceeded the number of larvae. However, by the 29th week, the number of larvae exceeded by far the number of adults and continued to do so throughout the continuation of the Survey. As has been noted previously, the increased preponderance of larvae is due not to diminished collections of adults but to increased collections of larvae. This correlates with the increased mosquito breeding due to improved meteorological conditions as shown in a subsequent part of this report.

Collections Per Square Mile As the plan of the Survey was made on the city and town as the area unit, the number of collections per square mile was different in the various communities. Collections were made in all the cities and towns except two. The number of collections per square mile averaged 9 (8.93). The scatter of the towns is charted in Figure VI. The chance variation was $9 \pm 2\sqrt{9}$ or 9 ± 6. This range of 3 to 15 collections per square mile, included 71 percent of the 349 towns in which collections were made. Therefore, there is a greater scatter in this distribution than may be expected by chance. The observed variation was actually 10.4; $9 \pm \sqrt{21}$ or a range from zero to 30 collections per square mile which included all but 8 of the communities. Three reasons are offered for the greater scatter of these towns than that which might be expected by chance. In some of the areas, the personnel composing the crews was not adapted to this type of work. The number of collections from the districts covered by these crews was much lower than the average. This factor accounts for those towns in which the number of collections was less than is to be expected. Those communities in which the headquarters of the crews were located invariably had larger collections and hence the collections per square mile were much greater. Actually, seven of the eight communities that had collections of 30 per square mile or more were those in which the headquarters were located. The third factor which increased this scatter was the contribution made by volunteer collectors. The response of these collectors varied greatly in different communities and was responsible for unusually high coverage in the communities of Brookline and those in Barnstable County. Lastly, it must be borne in mind that the towns vary greatly in area. This is a factor which cannot be practically evaluated. When a community was large, attempts were made to increase proportionately the amount of time during which collections were made each week.


NUMBER
SPECIMENS
FIGURE V
ADULTS & LARVAE
NUMBER OF SPECIMENS BY WEEKS
MASSACHUSETTS 1939
10000
1000
100
10
LEGEND
ADULTS
LARVAE
16
20
25
30
35
40
45
50

Population Effects on Mosquito Collections There were 346 communities in which collections were made by the Survey personnel throughout the greater portion of the Survey. The grouping of these communities is made in Table VI.

TABLE VI

RELATION OF POPULATION TO TOTAL MOSQUITO COLLECTIONS

ALL COMMUNITIES

Population	Number of Communities	Mean of Collections	Median of Collections
Under 500	38	103	85
501 - 1,000	30	112	110
1,001 - 2,500	89	118	100
2,501 - 5,000	63	99	91
5,001 - 10,000	54	129	91
10,001 - 25,000	40	140	120
25,001 - 50,000	14	119	135
50,001 - 100,000	11	118	115
Over 100,000	7	212	245
	346	121	105

The mean was 121 with a chance variation of $\sqrt{121}$ or 11. When 121 $\pm 2\sigma$ is taken as the expected limits of chance variation, all the groups of communities fall within this limit except one, that "Over 100,000". The explanation of this phenomena would seem to indicate that collections were greater in communities of over 100,000 and hence there were more collectors or mosquitoes were more numerous.

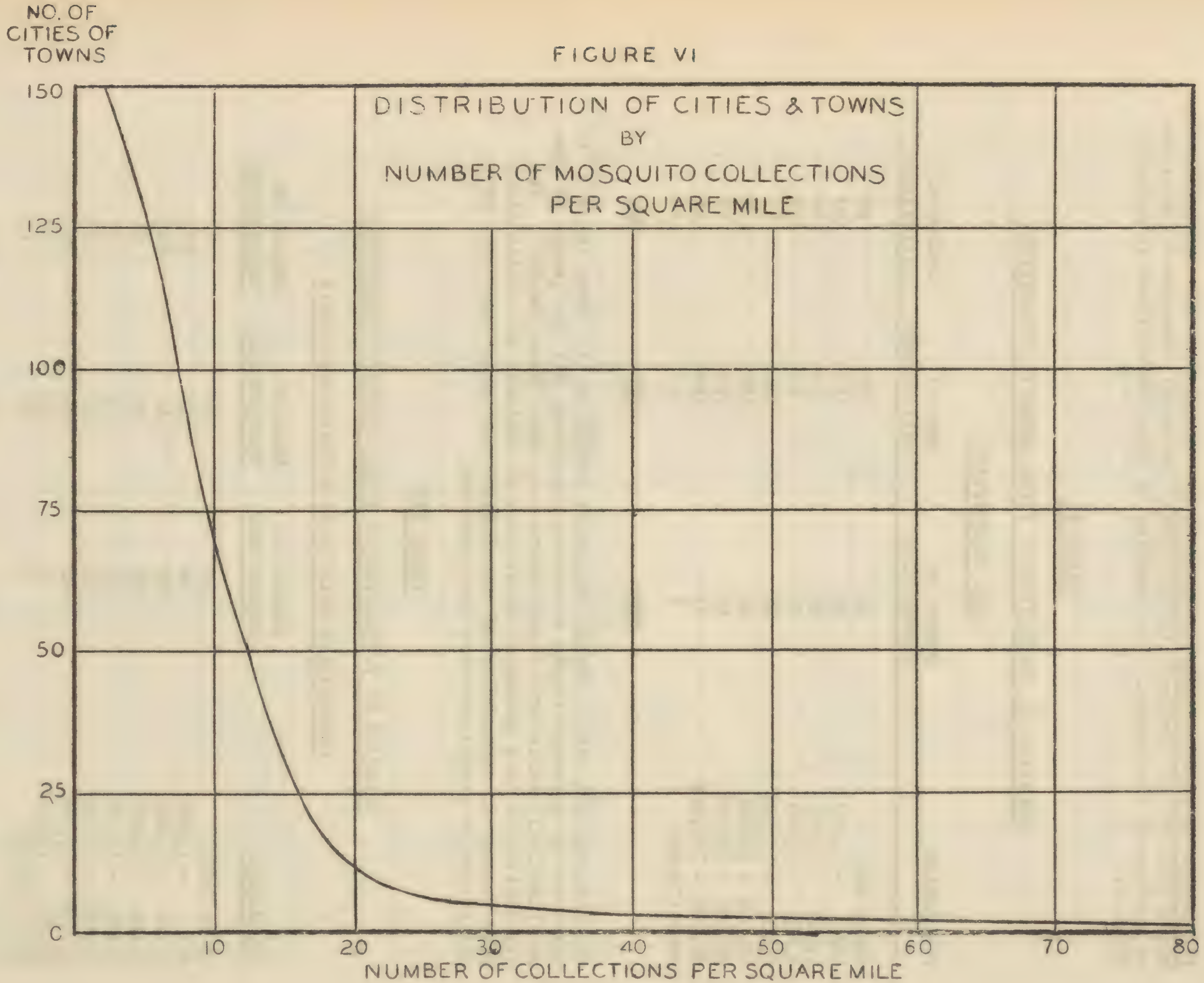
TABLE VII

RELATION OF POPULATION TO TOTAL MOSQUITO COLLECTIONS

Communities with Routine Collections Only

Population	Number of Communities	Mean of Collections	Median of Collections
Under 500	35	92	72
501 - 1,000	30	112	110
1,001 - 2,500	86	115	112
2,501 - 5,000	63	99	91
5,001 - 10,000	48	102	83
10,001 - 25,000	33	120	110
25,001 - 50,000	12	102	105
50,001 - 100,000	8	90	90
Over 100,000	1	45	45
Total	316	106	100

FIGURE VI



DISTRIBUTION OF CITIES & TOWNS
BY
NUMBER OF MOSQUITO COLLECTIONS
PER SQUARE MILE
NO. OF
CITIES OF
TOWNS
150
125
100
75
50
25
C
10
20
30
40
50
60
70
80
NUMBER OF COLLECTIONS PER SQUARE MILE

When a correction is introduced, the real facts are to be observed. The elimination of those communities where collectors were unusually active, indicates that there was no significant association of population and the number of collections made in the community. Table VII summarizes the data.

The mean now becomes 106 with a chance of 106 $\pm$ 10.3. The chance variation of 106 $\pm 2\sqrt{106}$, a range of 85 to 127 includes all population groups except those under 500 and over 100,000. Generally speaking, the communities with less than 500 population are inaccessible to collectors because of lack of roads and easy means of transportation. Since there is only one community in the group over 100,000, this cannot be taken as a sample of the whole, especially when it is recalled that the other seven had an average of over 250 collections. These seven were eliminated from this group because they were the headquarters of seven of the crew, and hence subject to more collecting than was routine.

It is apparent that there was no statistical relation between the population of the communities and the number of collections made in them. These facts taken into consideration support the evidence given above, that the samples of mosquitoes collected by the Survey are a true random and unselected sample, and, therefore, are representative of the mosquito population of the state.

CHAPTER X

METEOROLOGICAL CONDITIONS AND MOSQUITOES

There are twenty-six meteorological observation stations scattered throughout the Commonwealth which send their reports to the United States Weather Bureau in Boston. Weather data was obtained from them during the Survey. With the help of the chief of the Weather Bureau, we divided the state into areas surrounding each weather station in such a way as to obtain the best data on meteorological conditions in each community. Topography and meteorological data were factors to be considered in the formation of these areas.

Rain The relation of rainfall to mosquito collections is charted in Figure VII. The initial rise in collections during the 23rd to 25th week was due to the increased organization of the Survey. During the ensuing month and up to the beginning of the 31st week, the W. P. A. personnel was gradually penetrating into all communities in the state. The large increase in collections during July and the first week in August was due, not to an increase in personnel, but to an increase in the number of mosquitoes. However, the last three weeks of August were rather dry, and collections gradually levelled off.

It was confirmed by field observations that there is an increase in mosquito breeding one week after a heavy rain. However, the ponds and streams were so low that many remained below normal levels throughout the season. The association of rain and mosquitoes becomes more apparent on comparison of the 1938 and 1939 precipitation data. During 1938, Figure VIII, there was an accumulation of 11.7 inches of rain above normal, an excess of 26%. That year mosquitoes were unusually prevalent throughout the state. In 1939, there was a deficit of 5.5 inches of rain, 13% below normal. Mosquitoes were at no time as prevalent as in other years. The precipitation of the summers of 1938 and 1939 is compared with the normal in Figure IX. The 1938 rainfall was far above normal in June, July and September, in 1939 rainfall was below normal throughout the mosquito season.

It may be well at this time, to point out the association of rainfall to equine encephalomyelitis as observed in the 1938 outbreak. If the precipitation data is plotted similarly, Figure X, we find that July was a wet month. When the reported deaths are plotted on the same chart, it becomes evident that the peak of the outbreak occurred in the middle of August, or three to four weeks after the heavy rains of July. These facts correlate with the mosquito transmission of the disease. The development of the mosquito from egg to adult requires from one to two weeks. Upon emerging, the female must bite an infectious horse and undergo an extrinsic incubation period; if it survives, it must bite a second horse in order to transmit the disease. Assuming that the mosquito will not bite again for about three or four days after its first meal, a total of two to three weeks would elapse before a horse could be infected. As the curve plotted in Figure X was of deaths in horses, several days of illness of the animal must be included. It becomes apparent, therefore, that a definite time relationship exists between heavy

rainfall and outbreak of equine encephalomyelitis. In the 1938 outbreak, a peak was reached three or four weeks after a heavy rainfall. As precipitation decreased the disease diminished and, with the advent of killing frosts, disappeared.

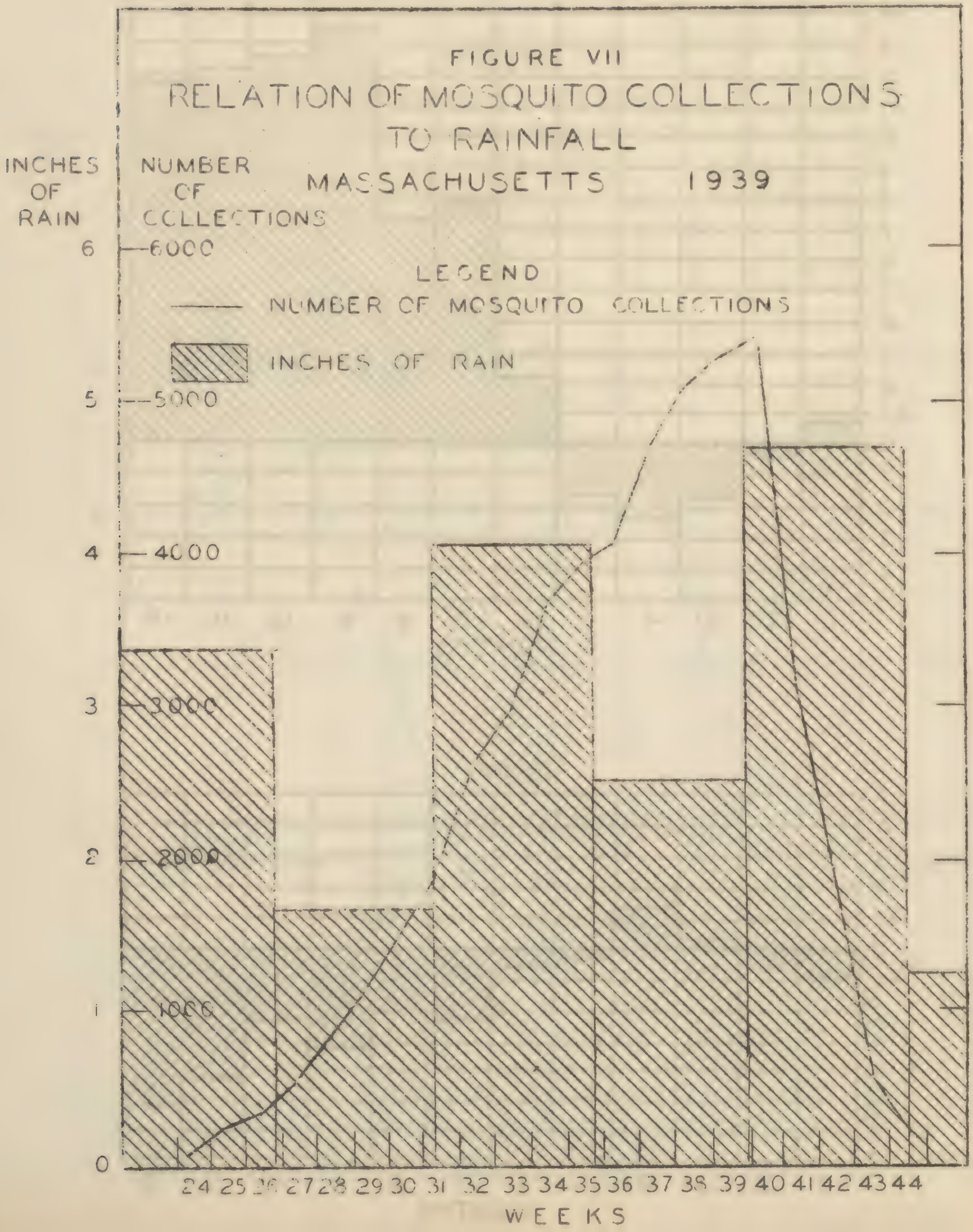
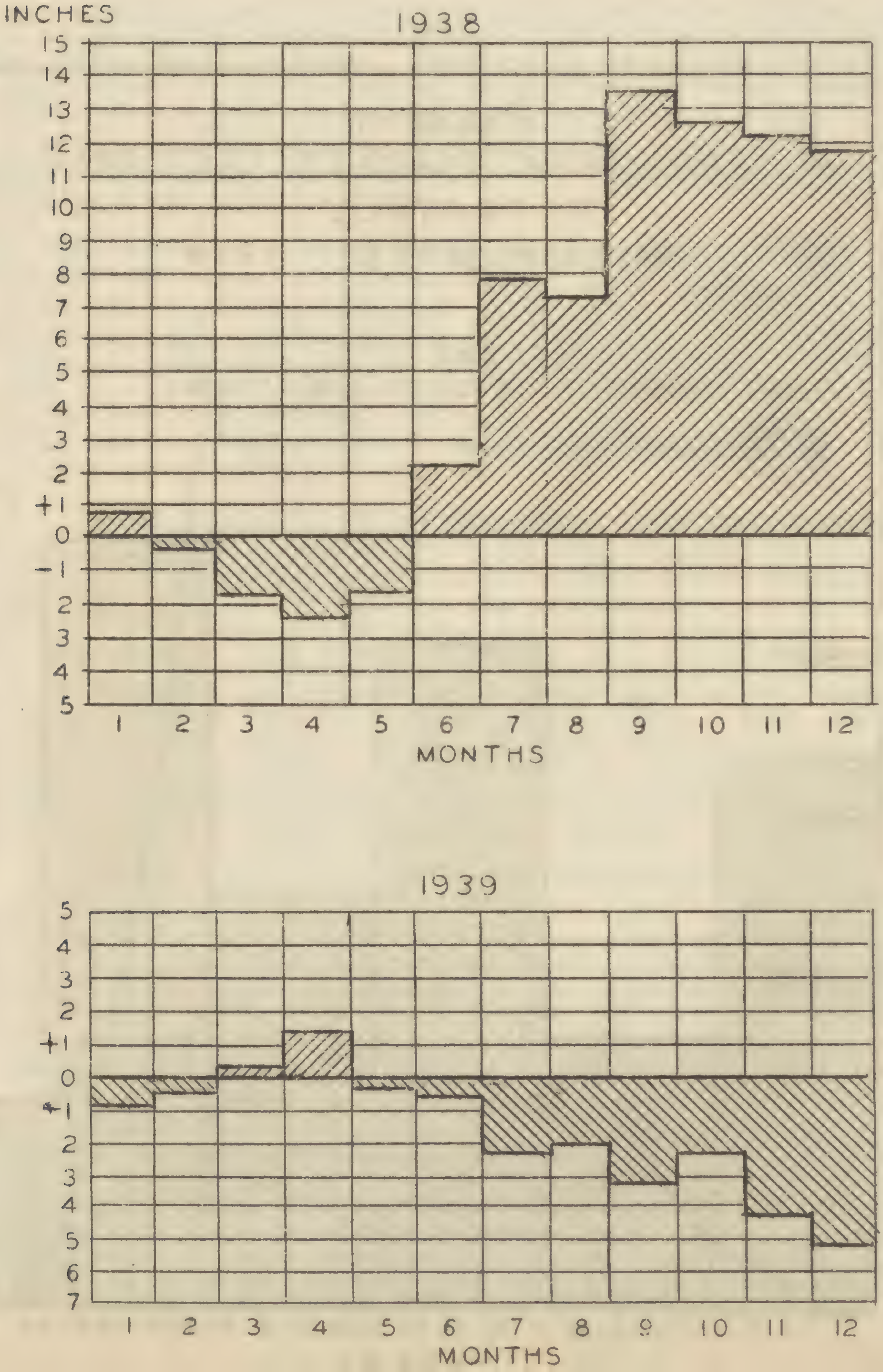


FIGURE VIII

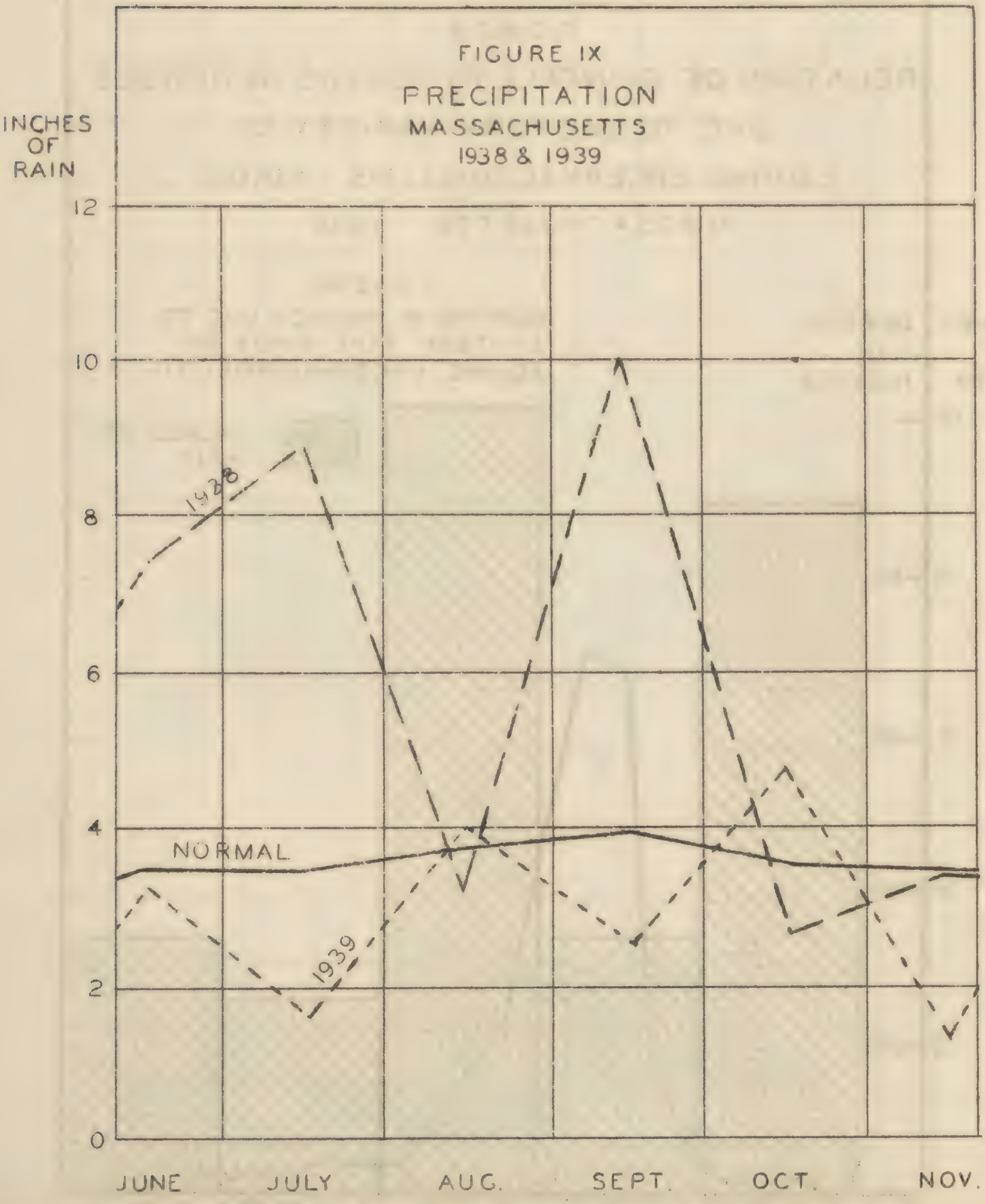
ACCUMULATION OF DAILY DEVIATION FROM NORMAL

IN INCHES

MASSACHUSETTS 1938-1939



Temperature During 1938, Figure XI, the temperature showed little deviation from normal. A deficit in Fahrenheit degree-days developed in April and remained unchanged through July. In August an excess accumulated which lasted through October. Warm weather is conducive to increased mosquito breeding. However, the slight excess which accumulated at the end of the summer had little effect because of the lack of rainfall.



Again we contrast 1939 with 1938 and find that 1938 was a more favorable year for mosquitoes. The summer of 1938 was not only wetter but warmer and mosquito breeding conditions were nearer the optimum.

During the 42nd week, frosts had appeared throughout central and northern Massachusetts. By the 44th week killing frosts appeared throughout most of the state except for the islands south of cape cod. No data has been collected upon the persistence of various species of mosquitoes beyond the end of October.

FIGURE X

RELATION OF RAINFALL TO DEATHS IN HORSES DUE TO EASTERN VARIETY OF EQUINE ENCEPHALOMYELITIS VIRUS MASSACHUSETTS 1938

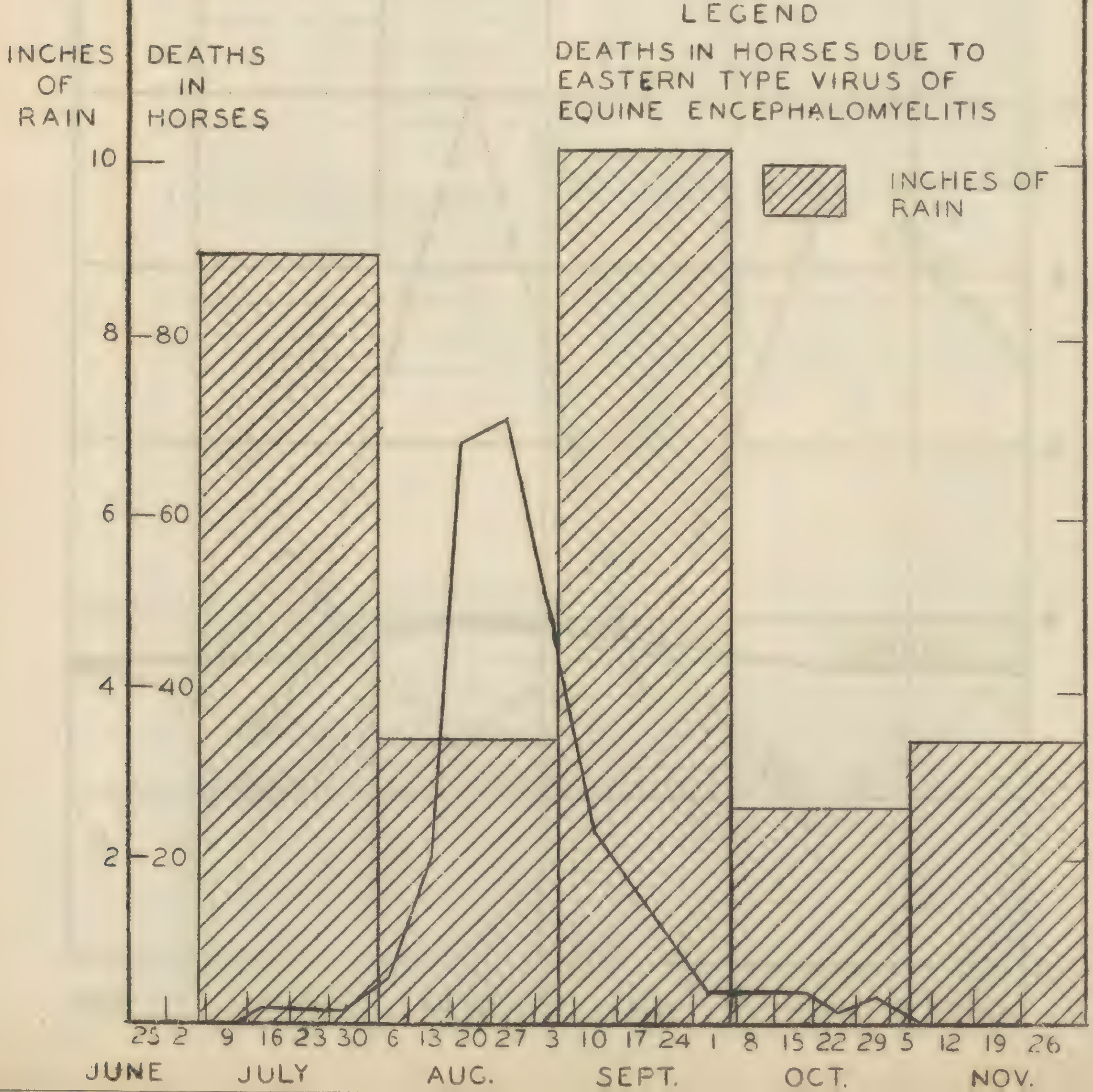
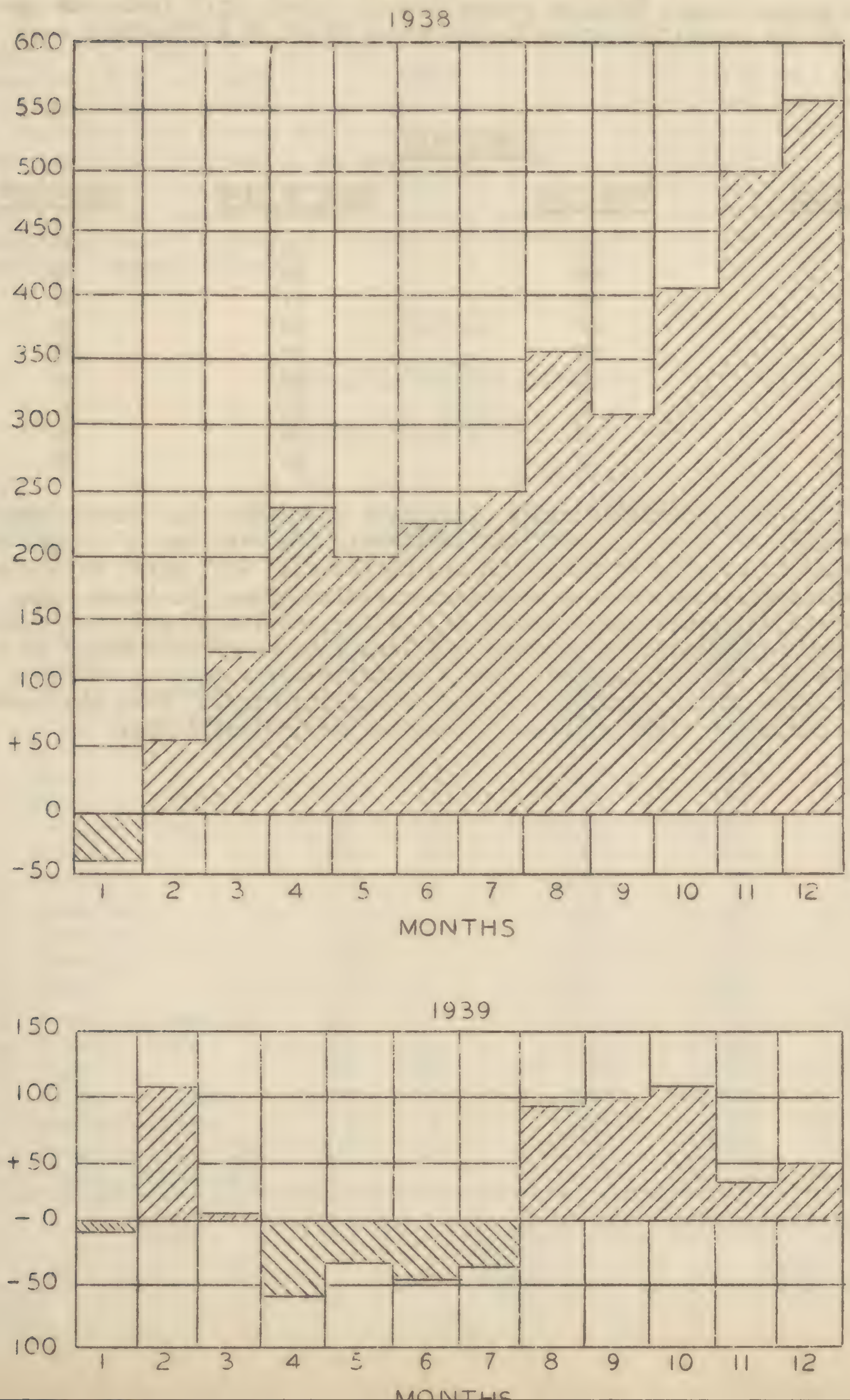


FIGURE XI
ACCUMULATION OF DAILY DEVIATION FROM NORMAL
IN FAHRENHEIT DEGREES
MASSACHUSETTS · 1938



Wind Adult mosquitoes, when borne by winds, will be disseminated over a large area in the direction of the wind. We determined the direction of prevailing winds for the towns in which collections were made by the Standard United States Weather Bureau Method. Table VIII lists the direction of the prevailing winds in the towns in which collections were made.

TABLE VIII

WEEK OF YEAR	DIRECTION	WEEK OF YEAR	DIRECTION
26	SW	35	W
27	SW	36	SW
28	SW	37	SW
29	SW	38	SW
30	SW	39	SW
31	W	40	NW
32	W	41	NW
33	W	42	NW
34	W	43	NW

As the prevailing winds throughout the middle and early parts of the summer are from the west and southwest, the carrying of mosquitoes by the wind is chiefly to the north and northeast. Salt marsh mosquitoes were, therefore, carried in a northeasterly direction. In those areas of the state which are northeast of salt water, adults of salt marsh mosquitoes may be expected to be farther inland than where salt water is to the northeast. The dissemination of a mosquito-borne disease would be more extensive in the direction of the prevailing winds. This observation was made during the 1938 outbreak of equine encephalomyelitis.

CHAPTER XI

MOSQUITO BREEDING PLACES

Each regular collection point was surveyed as described in Chapter VI. Table IX was compiled by punch card analysis from the data recorded in these surveys. No method of selection was used in picking out the breeding places; the crews were directed to collect samples from all the breeding places which they found, but they were not to take samples from identical sources in an area less than 100 yards in radius. There were twenty different types of breeding places included in our analysis: natural water bodies, marshes, swamps, ponds, lakes, rivers, streams and puddles were most frequent. Dumps and barrels were the two most common man-made breeding places.

TABLE IX

MOSQUITO BREEDING PLACES at REGULAR COLLECTION POINTS

Type of Breeding Places	No. of Breeding Places	No. of Species Collected	% of Species per Breeding Place	No. of Collections	Average No. Collections per Breeding Place
1. Artificial Pool	46	7	.15	435	9.5
2. Barrel	82	10	.12	789	9.6
3. Bird Bath, Flower Pot	6	4	.66	63	10.5
4. Cesspool or Overflow	14	7	.50	128	9.1
5. Cistern	9	5	.55	62	6.9
6. Dump	92	13	.14	1,064	11.6
7. Watering Trough	27	9	.33	273	10.1
8. Cranberry Bog	88	18	.20	1,352	15.4
9. Excavation	19	11	.57	185	9.7
10. Quarry	2	5	2.50	27	13.5
11. Sand Pit	7	6	.85	47	6.7
12. Root Hole	22	9	.41	175	7.9
13. Tree Hole	15	8	.53	187	12.5
14. Well	13	11	.84	169	13.0
15. Marsh or Swamp	637	15	.024	7,781	12.2
16. Pond or Lake	468	15	.032	5,025	10.7
17. Puddle	110	14	.127	1,012	9.2
18. River or Stream	1,173	17	.014	10,519	9.0
19. Rocky Crevice	9	8	.88	69	7.6
20. Running and Still Water Combined	382	18	.04	3,805	9.9
Total	3,221	-	$\sum = 9.467$	33,167	$\sum = 204.6$
			$\frac{\sum x}{m} = 47$		$\frac{\sum x}{m} = 10.3$

TABLE X

REGULAR COLLECTIONS OF LARVAE
in
DIFFERENT TYPES OF BREEDING PLACES

	AEDES									
	atropalpus	canadensis	cantator	cinereus	excrucians	intrudens	sollicitans	taeniorhynchus	triseriatus	vexans
1. Artificial Pool	-	1	1	-	-	-	-	-	-	-
2. Barrel	-	1	19	-	-	-	1	-	4	6
3. Bird Bath & Flower Pot	-	-	-	-	-	-	-	-	-	-
4. Cesspool & Overflow	1	-	-	-	-	1	-	-	-	-
5. Cistern	-	-	-	-	-	-	-	-	-	-
6. Dump	-	1	25	1	1	1	3	-	2	12
7. Watering Trough	1	-	-	-	-	-	-	-	1	1
8. Cranberry Bog	-	2	18	7	2	1	4	1	-	24
9. Excavation	-	-	-	-	-	-	1	-	-	-
10. Quarry	-	-	-	-	-	-	-	-	-	-
11. Sand Pit	-	-	-	-	-	-	-	-	-	-
12. Root Hole	-	-	-	-	-	-	-	-	-	-
13. Tree Hole	-	-	-	-	-	-	-	-	-	-
14. Well	-	-	-	-	-	-	-	-	2	1
15. Marsh & Swamp	7	5	105	22	-	-	85	-	-	118
16. Pond & Lake	16	8	9	7	-	-	2	-	-	41
17. Puddle	1	3	11	2	-	-	-	-	-	14
18. River or Stream	26	-	1	1	-	-	-	-	-	12
19. Rocky Crevice	1	-	-	-	-	-	-	-	-	1
20. Running & Still Water	-	6	44	21	-	6	-	-	-	32
	53	27	233	61	3	9	96	1	9	262

TABLE X

REGULAR COLLECTIONS OF LARVAE
in
DIFFERENT TYPES OF BREEDING PLACES

ANOPHELES			CULEX				THEOBALDIA		URANOTAENIA	
maculipennis	punctipennis	quadrimaculatus	apicalis	pipiens	salinarius	territans	melanura	morsitans	sapphirina	Column Number
-	111	37	251	78	6	-	-	-	-	1
-	47	5	129	435	8	-	-	-	-	2
-	8	-	18	36	1	-	-	-	-	3
-	7	11	29	76	3	-	-	-	-	4
-	6	1	30	24	1	-	-	-	-	5
-	58	33	315	569	43	-	-	-	-	6
1	28	5	61	171	4	-	-	-	-	7
-	69	29	980	100	54	31	11	5	13	8
2	22	7	65	71	3	13	-	-	2	9
-	3	-	9	13	1	1	-	-	-	10
-	5	2	18	18	1	3	-	-	-	11
-	11	7	54	40	8	27	26	-	1	12
-	13	10	58	59	8	25	13	-	1	13
-	19	3	56	47	1	37	-	-	1	14
10	703	216	2879	2198	364	786	125	-	158	15
8	686	331	2053	1217	88	369	34	-	156	16
1	131	34	327	393	18	64	7	-	6	17
16	2329	636	3055	3260	184	814	31	-	118	18
-	9	7	19	23	2	7	-	-	-	19
5	624	175	1385	841	105	364	21	-	89	20
43	4889	1549	11791	9669	903	2541	268	5	545	

The number of collections averaged 10.3 per breeding place. If chance is taken as $\sqrt{10.3}$ or 3.2; the chance variation of 10.3 ± 2(3.2), or a range of 3.9 to 16.7 includes all the breeding places. This indicates that the collection points were visited about the same number of times and that there is no statistical difference in the number of collections made in the different types of breeding places. This Survey, therefore, made an unselected collection of larvae from the various types of breeding places.

The number of species in the different types of breeding places varied from four in bird baths and flower pots to eighteen in cranberry bogs, and running and still water. The average number of species per breeding place is noted in Table IX. When the sum of these is divided by the number of types of breeding places, a mean of .47 is obtained for the series. The chance variation of this mean being 2 $\sqrt{.47}$, the chance distribution varies from .47 + 1.4 or 1.87 to .47 - 1.4 or 0.0. This range includes all types of breeding places except one, and statistically the distribution of species in the different types is not significant and may be due entirely to chance.

TABLE XI

CHARACTER OF WATER IN NATURAL WATER BODIES

Type of Water Body	No. of Collection Points	Brown	Colorless	Muddy	Floatage	Floatage & Brown	Floatage & Colorless	Floatage & Muddy	Unclassified
	Number of Collections								
Marsh & Swamp	637	146	179	191	-	22	17	19	63
Pond & Lake	468	84	271	42	-	7	24	2	38
Puddle	110	28	36	25	-	1	3	4	13
River or Stream	1173	209	653	130	1	24	27	27	102
Rocky Crevice	9	-	4	3	-	-	-	-	2
Running & Still Water	382	58	154	36	1	4	6	12	111
TOTAL	2779	525	1297	427	2	58	77	64	329
	Percent of Collections								
Marsh & Swamp	22.9	5.2	6.4	6.9	-	0.8	0.6	0.7	2.3
Pond & Lake	16.8	3.0	9.8	1.5	-	0.3	0.9	0.1	1.4
Puddle	4.0	1.0	1.3	0.9	-	-	.1	.1	0.5
River or Stream	42.2	7.5	23.5	4.7	-	0.9	1.0	1.0	3.7
Rocky Crevice	.3	-	0.1	0.1	-	-	-	-	0.1
Running & Still Water	13.8	2.1	5.5	1.3	-	0.1	0.2	0.4	4.0
TOTAL	100.0	18.9	46.7	15.4	0.0	2.1	2.8	2.3	11.8

This lack of significance is confirmed by the application of Student's formula for correlation. If the absolute value of r is less than $2/\sqrt{n-1}$, then there is no significance. Here r is calculated to be .23 and $2/\sqrt{n-1}$ is $2\sqrt{20-1}$ which equals $2\sqrt{19}$ $2/4.4 = .45$. Since this latter value is greater than r, there is no statistical significance in the number of species found in any of the breeding places.

The distribution of the species for each type of breeding place is included in Table IO. It includes only collections made at regular collection points. This table includes 32,907 collections of a total of 38,976. The importance of any type of breeding place for each species can be determined by calculating the percent of the total which was found in the type under consideration. It must be remembered that these different breeding places are an enumeration made by the Survey and do not represent a census of all such places. The conditions under which the Survey was made must be considered in interpreting this and all other data. The figures on larvae in this chapter apply to collections made at regular collection points, not to the total collections of the Survey.

TABLE XII

COLLECTIONS OF VECTOR LARVAE FROM BODIES OF WATER DIFFERENT IN CHARACTER

Number of Collections

Character of Water	AEDES ATROPALPUS	AEDES CANTATOR	AEDES SOLLICITANS	AEDES TAENIORHYNCHUS	AEDES TRISERIATUS	AEDES VEXANS	ANOPHELES QUADRIMACULATUS
Brown	7	28	3	-	1	50	279
Colorless	25	74	60	13	1	134	689
Muddy	-	30	15	1	2	61	193
Floatage	-	-	-	-	-	-	-
Floatage & Brown	-	-	-	-	1	3	39
Floatage & Colorless	1	-	-	-	-	5	43
Floatage & Muddy	-	1	-	-	-	5	11
TOTAL	33	133	78	14	5	258	1254

Percent of Collections

Character of Water	AEDES ATROPALPUS	AEDES CANTATOR	AEDES SOLLICITANS	AEDES TAENIORHYNCHUS	AEDES TRISERIATUS	AEDES VEXANS	ANOPHELES QUADRIMACULATUS
Brown	21	21	4	-	20	19	22
Colorless	76	55	77	93	20	52	55
Muddy	-	22	19	7	40	24	16
Floatage	-	-	-	-	-	-	-
Floatage & Brown	-	-	-	-	20	1	3
Floatage & Colorless	3	1	-	-	-	2	3
Floatage & Muddy	-	1	-	-	-	2	1
TOTAL	100	100	100	100	100	100	100

The breeding peculiarities of those species which are of public health importance is further analyzed in the following tables. There was a difference not only in the type of water collections in which various species breed but also in the character of the water. The nature of the water in the different types of natural water collections is analyzed in Table XI. Clear, colorless water was present in almost one-half of all collection points, brown water in about one-fifth and muddy in one-sixth. Clear streams represented one-fourth of the collection points. The collections of vectors of equine encephalomyelitis and of the principal carrier of malaria are correlated with the various characteristics of the water in Table XII. Aedes cantator, Aedes vexans, and Anopheles quadrimaculatus were collected in the different types of water as might be expected by chance. Aedes atropalpus, Aedes sollicitans, and Aedes taeniorhynchus were found in clear, colorless water more often than could be expected by chance. These three species, therefore, seem to prefer clear water to any other.

A second important characteristic of breeding places is the bottom of the water collection. The nature of the bottom effects the chemistry of

TABLE XIII

CHARACTER OF BOTTOM IN NATURAL WATER BODIES

Number of Collections

Type of Natural Water Body Collection	No. of Collection Points	No. with earth & Mud	No. with Leaves	No. with Rocks	No. with Sand	No. with Earth or Mud & Rocks	No. with vegetation	No. with Leaves & Other	Unclassified
Marsh & Swamp	637	312	3	6	14	32	11	127	132
Pond & Lake	468	208	4	4	30	36	3	71	112
Puddle	110	53	2	2	4	5	1	21	22
River or Stream	1173	427	-	39	82	137	4	138	346
Rocky Crevice	9	1	-	2	-	1	-	2	3
Running & Still Water	382	112	2	5	14	46	3	80	120
TOTAL	2779	1113	11	58	144	257	22	439	735

Percent of Collections

Type of Natural Water Body Collection	No. of Collection Points	No. with earth & Mud	No. with Leaves	No. with Rocks	No. with Sand	No. with Earth or Mud & Rocks	No. with vegetation	No. with Leaves & Other	Unclassified
Marsh & Swamp	22.7	11.2	0.1	0.2	0.5	1.1	0.4	4.5	4.7
Pond & Lake	16.6	7.4	0.1	0.1	1.1	1.3	0.1	2.5	4.0
Puddle	4.0	1.9	0.1	0.1	0.1	.2	-	0.8	0.8
River or Stream	42.3	15.4	-	1.4	3.0	4.9	0.1	5.0	12.5
Rocky Crevice	0.3	-	-	0.1	-	-	-	0.1	0.1
Running & Still Water	13.8	4.0	0.1	0.2	0.5	1.7	0.1	2.9	4.3
TOTAL	99.7	39.9	0.4	2.1	5.2	9.2	0.7	15.8	26.4

the water and also the type of vegetation that may grow in the water. This data is collected and summarized in Table XIII. Although about one-half of the collection points were characterized by clear, colorless water, the bottoms of an equal number of water bodies were composed chiefly of earth and mud. The association of these environmental factors upon the presence of the larvae of the vectors is shown in Table XIV. There is much less association of species and bottoms of water bodies than with species and types of water. Here, there is a wide scatter and there is no definite correlation in this series, except with Aedes atropalpus which prefers water bodies with rocky bottoms.

The type of vegetation growing in the water is a third important factor in the environment of larvae. Water plants effect the chemistry of the water, afford shelter against enemies and assist in preventing rough water during windy or stormy weather. The data on the existence of various types of vegetation in the water is tabulated in Table XV. In one-third of the water bodies, the type of vegetation was not classified; in most of these in-

TABLE XIV

COLLECTIONS OF VECTOR LARVAE FROM BODIES OF WATER WITH DIFFERENT BOTTOMS

Number of Collections

Character of Bottom	AEDES ATROPALPUS	AEDES CANTATOR	AEDES SOLLICITANS	AEDES TAENIORHYNCHUS	AEDES TRISERIATUS	AEDES VEXANS	ANOPHELES QUADRIMACULATUS
Earth or Mud	7	107	39	2	1	119	691
Leaves	-	-	-	-	-	2	4
Rock	11	-	-	-	-	8	11
Sand	-	8	1	-	-	24	73
Earth or Mud & Rock	1	-	-	-	-	9	122
Vegetation	-	13	40	13	-	6	3
Leaves & Other	-	17	2	-	2	37	150
TOTAL	19	145	82	15	3	205	1054

Percent of Collections

Character of Bottom	AEDES ATROPALPUS	AEDES CANTATOR	AEDES SOLLICITANS	AEDES TAENIORHYNCHUS	AEDES TRISERIATUS	AEDES VEXANS	ANOPHELES QUADRIMACULATUS
Earth or Mud	37	74	48	13	33	58	66
Leaves	-	-	-	-	-	1	-
Rock	58	-	-	-	-	4	1
Sand	-	5	1	-	-	12	7
Earth or Mud & Rock	5	-	-	-	-	4	12
Vegetation	-	9	49	87	-	3	-
Leaves & Other	-	12	2	-	67	18	14
TOTAL	100	100	100	100	100	100	100

stances, there was very little vegetation, too little to be classified as characteristic of the collection point. Lily pads were the most commonly recognized water plant, algae were the second and duckweed third in numerical order. The association of larvae with these plants is given in Table XVI. As is to be expected, there is a negative correlation between lily pads and the salt marsh mosquitoes because lily pads seldom grow in brackish water. Aedes atropalpus is associated with algae where this plant was prominent enough to be marked as characteristic of the collection point. This indicated that Aedes atropalpus prefers clear, colorless water with rocky bottoms where algae is the principal water plant.

The vegetation which grows at the water edge and in shallow water is even more important than the water plants. Marsh grass, cat-tails and other similar plants afford greater protection against rough water and

TABLE XV

KINDS OF VEGETATION IN NATURAL WATER BODIES

Number of Collections

Type of Water Body	No. of Collection Points	Unclassified	No. with Lily Pads	No. with Algae	No. with Duckweeds	No. with Water Mosses	No. with Lily Pads & Other	No. with Algae & Other	No. with Duckweeds & Other
Marsh & Swamp	637	163	92	62	25	51	135	89	20
Pond & Lake	468	96	69	26	6	33	185	49	4
Puddle	110	66	1	6	6	11	5	13	2
River or Stream	1173	506	60	88	54	150	152	127	36
Rocky Crevice	9	5	1	-	-	2	1	-	-
Running & Still Water	382	96	19	24	11	34	137	51	10
TOTAL	2779	932	242	206	102	281	615	329	72

Percent of Collections

Type of Water Body	No. of Collection Points	Unclassified	No. with Lily Pads	No. with Algae	No. with Duckweeds	No. with Water Mosses	No. with Lily Pads & Other	No. with Algae & Other	No. with Duckweeds & Other
Marsh & Swamp	22.9	5.9	3.3	2.2	.9	1.8	4.8	3.2	.7
Pond & Lake	16.8	3.4	2.5	0.9	.2	1.1	6.7	1.7	1.4
Puddle	3.9	2.4	.0	.2	.2	.4	.2	.5	.1
River or Stream	42.2	18.2	2.2	3.1	1.9	5.4	5.5	4.6	1.3
Rocky Crevice	0.3	.2	-	-	-	.1	-	-	-
Running & Still Water	13.7	3.4	.7	.9	.4	1.2	4.9	1.8	.4
TOTAL	99.8	32.4	8.7	7.3	3.6	10.0	22.1	11.8	3.9

against natural enemies than do water plants. Often these plants interfere with mosquito-control measures. The occurrence of these plants in the various types of breeding places is summarized in Table XVII. Marsh grass was the most commonly recognized plant at the edges of water bodies, being almost twice as frequent as cat-tails and reeds. Other plants were observed in too small a number to justify any attempts at statistical analysis.

The association of plants at the water edge and larvae is made in Table XVIII. The highest association is between Aedes taeniorhynchus and marsh grass. There is a significant association between salt marsh mosquitoes and marsh grass. Aedes vexans and Anopheles quadrimaculatus were collected with the chance frequency in association with different types of vegetation.

Lastly, not all species were found in the same collection point. Certain species were found in the same water collection with a greater fre-

TABLE XVI

COLLECTIONS OF VECTOR LARVAE FROM BODIES OF WATER WITH DIFFERENT VEGETATION

Number of Collections

Vegetation in Water	AEDES ATROPAL-PUS	CANTA-TOR	SOLLICI-TANS	TAENIO-RHYNCHUS	TRISERI-ATUS	VEXANS	ANOPHELES QUADRI-MACULATUS
Lily Pads	-	1	-	-	1	21	83
Algae	3	46	55	15	-	18	112
Duckweeds	-	-	-	-	1	3	72
Water Mosses	-	53	12	-	-	23	159
Lily Pads & Other	1	5	4	14	-	50	440
Algae & Other	13	41	14	-	1	41	204
Duckweeds & Other	-	11	-	-	-	19	54
TOTAL	17	157	85	29	3	175	1127

Percent of Collections

Vegetation in Water	ATROPAL-PUS	CANTA-TOR	SOLLICI-TANS	TAENIO-RHYNCHUS	TRISERI-ATUS	VEXANS	QUADRI-MACULATUS
Lily Pads	-	1	-	-	33	12	8
Algae	18	29	65	52	-	10	10
Duckweeds	-	-	-	-	33	2	6
Water Mosses	-	34	14	-	-	13	14
Lily Pads & Other	6	3	5	48	-	29	39
Algae & Other	76	26	16	-	34	23	18
Duckweeds & Other	-	7	-	-	-	11	5
TOTAL	100	100	100	100	100	100	100

quency than others. The larval associates of the vectors of equine encephalomyelitis and of malaria are summarized in Table XIX. *Aedes atropalpus* was found to be most frequently associated with *Culex pipiens*. All other vectors were associated with *Culex apicalis* and *Culex pipiens* to about the same degree. In addition, *Anopheles quadrimaculatus* was equally associated with *Anopheles punctipennis*. It is to be noted that these associates are between species collected in a collection point one hundred yards in diameter throughout the entire season. The species may not have been collected at the same time nor from the same water collection. However, in the majority of the cases, there was only one water body at a collection point and, therefore, the associations hold as to place better than as to time. The salt marsh breeds were collected from the same water bodies as the *Culex*. These associations were frequently encountered among specimens contained in vials received at the laboratory.

There is very little positive association between the various salt marsh mosquitoes. This observation may be explained in part by the fact that

TABLE XVII

KINDS OF VEGETATION AT EDGE OF NATURAL WATER BODIES

Number of Collections

Type of Water Body	No. of Collections	No. with Cattails & Reeds	No. with Pickerel Weeds	No. with Arrow Heads	No. with Bulrushes	No. with Marsh Grass	No. with Cattails, Reeds & Other	No. with Marsh Grass & Other	No. with Unclassified Vegetation
Marsh & Swamp	637	25	5	6	10	170	228	95	104
Pond & Lake	468	12	3	8	4	119	143	87	92
Puddle	110	2	2	-	4	24	9	6	63
River or Stream	1173	23	22	22	10	399	174	211	312
Rocky Crevice	9	-	-	-	-	1	-	1	7
Running & Still Water	382	2	1	5	-	82	175	66	53
TOTAL	2779	64	33	41	28	795	721	466	631

Percent of Collections

Type of Water Body	No. of Collections	No. with Cattails & Reeds	No. with Pickerel Weeds	No. with Arrow Heads	No. with Bulrushes	No. with Marsh Grass	No. with Cattails, Reeds & Other	No. with Marsh Grass & Other	No. with Unclassified Vegetation
Marsh & Swamp	22.9	0.9	0.2	0.2	0.4	6.1	7.9	3.4	3.7
Pond & Lake	16.8	.4	0.1	0.3	0.1	4.2	5.1	3.1	3.3
Puddle	4.0	0.1	0.1	-	0.1	0.9	0.3	0.2	2.3
River or Stream	42.2	0.8	0.8	0.8	0.4	14.4	6.3	7.6	11.2
Rocky Crevice	.3	-	-	-	-	-	-	-	.3
Running & Still Water	13.8	0.1	-	0.2	-	3.0	6.2	2.4	1.9
TOTAL	100.0	2.3	1.2	1.5	1.0	28.6	25.8	16.7	22.7

Aedes cantator may breed in water containing less salt than that in which Aedes sollicitans breed. The fresh water Aedes vectors are significantly associated with Culex territans which was collected in much smaller numbers than other species of Culex.

TABLE XVIII

COLLECTIONS OF VECTOR LARVAE FROM BREEDING PLACES

WITH DIFFERENT VEGETATION AT WATER-EDGE

Number of Collections

Vegetation at Water-Edge	AEDES ATROPAL-PUS	CANTA-TOR	SOLLICI-TANS	TAENIO-RHYNCHUS	TRISERI-ATUS	VEXANS	ANOPHELES QUADRI-MACULATUS
Cat-tails & Reeds	-	-	-	-	-	9	49
Pickerel Weeds	-	1	-	-	-	5	22
Arrow Heads	-	-	-	-	-	3	27
Bulrush	-	-	-	-	-	1	1
Marsh Grass	17	70	65	15	2	72	409
Cat-tails, Reeds & Other	1	52	22	-	2	71	378
Marsh Grass & Other	3	37	5	-	-	55	256
TOTAL	21	160	92	15	4	216	1142

Percent of Collections

Vegetation at Water-Edge	AEDES ATROPAL-PUS	CANTA-TOR	SOLLICI-TANS	TAENIO-RHYNCHUS	TRISERI-ATUS	VEXANS	ANOPHELES QUADRI-MACULATUS
Cat-tails & Reeds	-	-	-	-	-	4	4
Pickerel Weeds	-	1	-	-	-	2	2
Arrow Heads	-	-	-	-	-	2	3
Bulrush	-	-	-	-	-	1	-
Marsh Grass	81	44	71	100	50	33	36
Cat-tails, Reeds & Other	5	32	24	-	50	33	33
Marsh Grass & Other	14	23	5	-	-	25	22
TOTAL	100	100	100	100	100	100	100

In all these tables only a few attempts have been made to interpret the data. Too many factors are concerned in the ecology and bionomics of mosquitoes to assign any one observation to a peculiar circumstance without due consideration of all other factors. For this reason, the observed facts have been presented without much comment so that the reader may make such interpretation as his experience and knowledge permit.

TABLE XIX

LARVAL ASSOCIATES

Number of Collections

SPECIES	AEDES ATROPAL-PUS	AEDES CANTA-TOR	AEDES SOLLICI-TANS	AEDES TRISERI-ATUS	AEDES VEXANS	ANOPHELES QUADRI-MACULATUS
Aedes atropalpus	-	-	-	-	41	9
A.canadensis	-	12	1	-	6	2
A.cantator	-	-	50	1	80	9
A.cinereus	-	15	4	-	31	10
A.excrucians	-	-	-	-	3	-
A.fitchii	-	-	-	-	-	-
A.intrudens	1	-	-	-	3	-
A.sollicitans	-	83	-	-	-	-
A.stimulans	-	-	-	-	-	-
A.taeniorhynchus	-	15	16	-	-	-
A.triseriatus	-	1	-	-	2	-
A.vexans	13	45	11	2	-	70
Anopheles punctipennis	30	13	8	10	382	1857
A.quadrimaculatus	2	9	14	-	82	-
Culex apicalis	34	449	123	43	1088	2394
C.pipiens	89	368	135	43	844	1837
C.salinarius	3	215	91	-	109	188
C.territans	47	63	15	42	438	559
Theobaldia melanura	-	47	8	1	42	13
T.morsitans	-	-	-	-	1	1
TOTAL	219	1335	476	142	3152	6949

Percent of Collections

SPECIES	AEDES ATROPAL-PUS	AEDES CANTA-TOR	AEDES SOLLICI-TANS	AEDES TRISERI-ATUS	AEDES VEXANS	ANOPHELES QUADRI-MACULATUS
Aedes atropalpus	-	-	-	-	01.3	00.1
A.canadensis	-	00.9	00.1	-	00.2	-
A.cantator	-	-	10.5	00.7	02.5	00.1
A.cinereus	-	01.1	00.8	-	01.0	00.1
A.excrucians	-	-	-	-	00.1	-
A.fitchii	-	-	-	-	-	-
A.intrudens	00.5	-	-	-	00.1	-
A.sollicitans	-	06.2	-	-	-	-
A.stimulans	-	-	-	-	-	-
A.taeniorhynchus	-	01.1	03.4	-	-	-
A.triseriatus	-	00.1	-	-	00.1	-
A.vexans	05.9	03.4	02.3	01.4	-	01.0
Anopheles punctipennis	13.7	01.0	01.7	07.0	12.1	26.7
A.quadrimaculatus	00.9	00.7	02.9	-	02.6	-
Culex apicalis	15.5	33.6	25.8	30.3	34.5	34.5
C.pipiens	40.6	27.6	28.4	30.3	26.8	26.4
C.salinarius	01.4	16.1	19.1	-	03.5	02.7
C.territans	21.5	04.7	03.2	29.6	13.9	08.0
Theobaldia melanura	-	03.5	01.7	00.7	01.3	00.2
T.morsitans	-	-	-	-	-	-
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

CHAPTER XII

THE COLLECTION OF ADULT MOSQUITOES

Adult mosquitoes were collected by two methods. The most important of these was the capture of specimens by the killing tube, which was placed directly over the resting mosquito. The second method was sweeping with nets. As the collectors were novices in using the net, and since some experience is required in its manipulation, this method was less productive than the former. There were 23,719 specimens in 8,100 collections. Adults represented 16.5% of the total collections. Although 75% or more of the adults were collected by the personnel of the Survey, and, hence, represented collections of those adults with diurnal habits, the remainder of the collections were made by volunteers and represent mosquitoes with nocturnal habits.

Biting Habits This data is summarized in the following series of tables. Table XX, Adult Mosquitoes Caught on Man, is a list of those mosquitoes which were collected by placing the killing tube over a mosquito which was resting on a person's body. Although the mosquito may not have been biting, it presumably was attracted to man in the anticipation of obtaining

TABLE XX

ADULT MOSQUITOES CAUGHT ON MAN

SPECIES	NUMBER OF SPECIMENS	PERCENT
Aedes sollicitans	738	37.3
Mansonia perturbans	511	25.8
Aedes cantator	311	15.7
Aedes vexans	120	6.0
Aedes aurifer	52	2.6
Aedes canadensis	50	2.5
Aedes cinereus	47	2.4
Culex pipiens	42	2.1
Aedes excrucians	20	1.1
Aedes intrudens	19	0.9
Culex salinarius	14	0.7
Aedes taeniorhynchus	12	0.6
Culex territans	10	0.5
Anopheles punctipennis	7	0.4
Culex apicalis	6	0.3
Aedes fitchii	4	0.2
Aedes triseriatus	3	0.2
Theobaldia melanura	3	0.2
Aedes species unidentified	3	0.2
Aedes stimulans	2	0.1
Anopheles quadrimaculatus	2	0.1
Aedes dorsalis	1	0.0
	1977	99.9

a blood meal. Aedes sollicitans is the most numerous offender. Mansonia perturbans was a ferocious biter, but, because of its early seasonal incidence, soon ceased to be a nuisance. Aedes sollicitans was more numerous towards the middle and end of the mosquito season. Aedes cantator and Aedes vexans were more prevalent during the middle of the season. These last three are vectors of equine encephalomyelitis and were the three most numerous biters.

There was some variation in the mosquitoes which were collected inside houses and those which were collected on man. Those which were collected inside houses were contributed by volunteers who were interested in finding out what mosquitoes interrupted their slumbers. The following table, therefore, represents mosquitoes with greater nocturnal biting habits as contrasted with those in Table XX, where diurnal activity predominated.

TABLE XXI

ADULT MOSQUITOES CAUGHT IN HOUSES

SPECIES	NUMBER OF SPECIMENS	PERCENT
Culex pipiens	973	31.1
Mansonia perturbans	911	29.1
Anopheles quadrimaculatus	407	13.0
Culex apicalis	189	6.0
Culex territans	165	5.3
Culex salinarius	85	2.7
Aedes cantator	56	1.8
Aedes sollicitans	56	1.8
Anopheles punctipennis	46	1.5
Aedes vexans	44	1.4
Anopheles maculipennis	27	0.9
Culex species unidentified	26	0.8
Anopheles walkeri	23	0.7
Aedes triseriatus	19	0.6
Aedes canadensis	17	0.5
Theobaldia melanura	14	0.4
Aedes atropalpus	12	0.4
Aedes excrucians	12	0.4
Aedes aurifer	11	0.3
Aedes cinereus	10	0.3
Aedes trivittatus	9	0.3
Aedes fitchii	6	0.2
Aedes intrudens	3	0.1
Aedes species unidentified	3	0.1
Chaoborinae species unidentified	3	0.1
Aedes stimulans	1	0.0
Aedes punctor	1	0.0
Theobaldia morsitans	1	0.0
	3130	99.8

Culex pipiens and Mansonia perturbans are the most frequent invaders. Anopheles quadrimaculatus, the malaria vector, is third. Culex apicalis

which is described as a biter of cold-blooded animals, was fourth in this series. The *Aedes* mosquitoes were infrequent invaders of homes and were not a serious menace inside buildings. This observation indicates that the greatest danger from vectors of equine encephalomyelitis is outdoors.

In evaluating the data above, it is necessary to point out that all mosquitoes do not enter houses with the intent to bite. Although most mosquitoes are attracted indoors with the prospect of a blood meal, some species, such as *Culex apicalis* enter houses to hibernate. With the approach

TABLE XXII

ADULT MOSQUITOES CAUGHT ON MAN AND IN HOUSES

SPECIES	NUMBER OF SPECIMENS	PERCENT
Mansonia perturbans	1,422	27.8
Culex pipiens	1,015	19.8
Aedes sollicitans	794	15.5
Anopheles quadrimaculatus	409	8.0
Aedes cantator	367	7.1
Culex apicalis	195	3.8
Culex territans	175	3.4
Aedes vexans	164	3.2
Culex salinarius	99	1.9
Aedes canadensis	67	1.3
Aedes aurifer	63	1.2
Aedes cinereus	57	1.1
Anopheles punctipennis	53	1.0
Aedes excrucians	32	0.6
Anopheles maculipennis	27	0.5
Culex species unidentified	26	0.5
Anopheles walkeri	23	0.5
Aedes triseriatus	22	0.4
Aedes intrudens	22	0.4
Theobaldia melanura	17	0.3
Aedes atropalpus	12	0.2
Aedes taeniorhynchus	12	0.2
Aedes fitchii	10	0.2
Aedes trivittatus	9	0.2
Aedes species unidentified	6	0.1
Chaoborinae species unidentified	3	0.1
Aedes stimulans	3	0.1
Aedes dorsalis	1	0.0
Aedes punctor	1	0.0
Theobaldia morsitans	1	0.0
	5,107	99.4

of cold weather, mosquitoes are more likely to seek warm winter quarters. When the mosquitoes caught in houses are added to those which are caught on man, a better index of the biting mosquitoes can be obtained. This data

is compiled in Table XXII. Here the species are rearranged as to their numerical importance: Mansonia perturbans heads the list, Culex pipiens is second, Aedes sollicitans is third and Anopheles quadrimaculatus, fourth. Among the species captured in houses, the vectors of equine encephalomyelitis represent about one-fourth of the total number of specimens.

TABLE XXIII

ADULT MOSQUITCES CAUGHT IN BARN AND STABLE

SPECIES	NUMBER OF SPECIMENS	PERCENT
Culex pipiens	98	46.4
Mansonia perturbans	35	16.6
Aedes vexans	18	8.5
Aedes cantator	14	6.6
Culex salinarius	13	6.2
Culex apicalis	8	3.8
Anopheles quadrimaculatus	4	1.9
Culex territans	4	1.9
Culex species unidentified	4	1.9
Aedes cinereus	3	1.4
Aedes excrucians	3	1.4
Anopheles punctipennis	3	1.4
Aedes atropalpus	1	0.5
Aedes fitchii	1	0.5
Aedes sollicitans	1	0.5
Aedes stimulans	1	0.5
	211	100.0

Table XXIII lists the mosquitoes caught in barns and stables. Presumably, the main attraction was the prospect of a blood meal. Here, however, the blood was not from man, but from horses, cattle and other domestic animals. A second urge which became effective with the onset of cold weather, was the seeking of a warm place in which to hibernate. Culex pipiens was by far the most frequent invader of the barn and stable. Mansonia perturbans was the second in numerical importance and Aedes vexans, third. Aedes sollicitans, which is a ferocious biter of man, was caught only once inside a barn or stable. The collection of adults in relation to the density of buildings is discussed in subsequent parts of this report.

Environment The collection of those species of mosquitoes which are of public health importance in different types of terrain is summarized in Table XXIV. This data is based on adults caught at regular collection points. It is to be expected that collections were made more often in certain types of terrain in preference to others. Cultivated fields were seldom trespassed upon and,hence,only a few collections were made here.The description of the collection point area as given in this table is the chief character of the land included in the one hundred yard radius of the collection point. In many instances, other types of terrain were also present, but represented only a small portion of the collection point area. The totals on the left of Table XXIV furnish a base against which the species data can be compared. Aedes cantator and Aedes sollicitans were caught with about equal frequency in

meadows and in woods. Aedes vexans was captured most frequently in the woods. The preference of this mosquito for the woods is an important factor in any control-program that may be instituted against equine encephalomyelitis. Horses should be removed from pastures that are in close proximity to

TABLE XXIV

ASSOCIATION OF VECTOR ADULTS

WITH DIFFERENT TYPES OF TERRAIN

Number of Collections

	AEDES						ANOPHELES	TOTALS
Nature of terrain	atropalpus	cantator	sollicitans	taeniorhynchus	triseriatus	vexans	quadrimaculatus	totals
Cultivated Fields	-	7	10	-	-	7	3	27
Meadow-Pastured	-	11	32	1	4	1	2	51
Meadow-Unpastured	-	102	177	8	2	16	10	315
Rocky	-	-	-	-	-	1	3	4
Woods	-	67	92	3	16	56	14	248
Meadow & Woods	-	70	99	1	5	24	5	204
Meadows & Cultivated Fields	1	11	20	-	2	4	2	40
TOTAL	1	268	430	13	29	109	39	889

Percent of Collections

Cultivated Fields	-	2.6	2.6	-	-	6.4	7.7	3.0
Meadow-Pastured	-	4.1	7.4	7.7	13.8	0.9	5.1	5.7
Meadow-Unpastured	-	38.1	41.1	61.5	6.8	14.6	25.6	35.5
Rocky	-	-	-	-	-	.9	7.7	.4
Woods	-	25.0	21.3	23.1	55.5	51.3	35.9	27.9
Meadow & Woods	-	26.1	23.1	7.7	17.2	22.0	12.8	23.0
Meadows & Cultivated Fields	100.0	4.1	4.6	-	6.8	3.7	5.1	4.5
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

woods, and people should refrain from entering woods during outbreaks of this disease. In this way, exposure to Aedes vexans which may be infectious will be greatly reduced. If we could apply the data collected by this Survey, it seems apparent that one-half of the exposures to Aedes vexans would be eliminated simply by keeping away from woods. These facts seem to apply to Aedes triseriatus and Anopheles quadrimaculatus, the principal vector of malaria; however, the number of collections in both these instances is smaller and statistically this conclusion is less certain. Aedes atropalpus and Aedes taeniorhynchus were captured in too small a number to permit any significant inference.

In Table XXV the association is made of vectors to various types

of trees. Here again it must be remembered that the data is based on collections from regular collection points, and that the trees described were the predominating type in the collection point area one hundred yards in radius. Hardwoods are much more numerous in Massachusetts than any other type of tree. In estimating the significance of any association, the total collections must, therefore, be used as a base. There appears to be no other association than a chance distribution in all instances except on that of Aedes vexans and mixed trees where more adults were captured than might be

TABLE XXV

ASSOCIATION OF VECTOR ADULTS WITH DIFFERENT TYPES OF TREES

Number of Collections

	AEDES						ANOPHELES	TOTALS
TREES	atropalpus	cantator	sollicitans	taeniorhynchus	triseriatus	Vexans	quadrimaculatus	totals
Evergreen	-	7	16	-	-	1	-	24
Hardwood	2	151	254	14	12	28	25	486
Willow	-	4	7	-	-	9	-	13
Fallen Trees	-	-	-	-	-	-	2	2
Burned Trees	-	-	-	-	-	-	-	-
Evergreen & Hardwood	1	85	108	-	11	88	10	303
Fallen Trees & Evergreen or Hardwood	-	32	64	40	12	13	9	170
TOTAL	3	279	449	54	35	132	46	998
			Percent of Collections					
Evergreen	-	2.5	3.5	-	-	.8	-	2.4
Hardwood	66.6	54.1	56.5	25.9	34.2	21.2	54.3	48.7
Willow	-	1.4	1.5	-	-	1.5	-	1.3
Fallen Trees	-	-	-	-	-	-	4.3	.2
Burned Trees	-	-	-	-	-	-	-	-
Evergreen & Hardwood	33.3	30.4	24.1	-	31.4	66.6	21.7	30.4
Fallen Trees & Evergreen or Hardwood	-	11.4	14.2	74.1	34.2	9.8	19.5	17.1
TOTAL	99.9	99.8	99.8	100.0	99.8	99.9	99.8	100.1

expected by chance. This may indicate that in general there is no association between any type of trees and any of the vectors. The unexpectedly large number of adults of Aedes vexans captured in mixed woods is difficult to explain as specimens were captured in smaller numbers among hardwood and also evergreen trees. The numbers, however, are too small to be conclusive.

CHAPTER XIII

VECTORS OF EQUINE ENCEPHALOMYELITIS

Numerical Importance of Vectors There are six mosquitoes in Massachusetts which have been demonstrated in the laboratory to transmit the eastern virus. These are all *Aedes* mosquitoes. Their numerical importance in relation to other species, both vectors and non-vectors, is discussed in this chapter. The geographical and seasonal distribution, the life habits and public health importance of such species is discussed in Chapter XV.

TABLE XXVI

NUMERICAL IMPORTANCE OF
VECTORS OF EQUINE ENCEPHALOMYELITIS
BY SPECIMENS

SPECIES	LARVAE Number	LARVAE %	ADULT Number	ADULT %	Specimens	Numerical Importance in %
Aedes atropalpus	993	94.3	60	5.7	1,053	7.8
A. cantator	2,704	67.0	1,329	33.0	4,033	29.7
A. sollicitans	1,054	29.3	2,548	70.7	3,602	26.6
A. taeniorhynchus	112	84.8	20	15.2	132	1.0
A. triseriatus	92	29.7	228	71.3	320	2.4
A. vexans	3,358	76.0	1,052	24.0	4,410	32.5
TOTAL	8,313	61.3	5,237	38.7	13,550	100.0

In Table XXVI the vectors are evaluated on the basis of the number of specimens collected. *A. vexans* is the most numerous, *A. cantator* and *A. sollicitans* are second and third respectively, in numerical importance. The other three vectors are far below these in numbers. The percent of adult specimens was highest in *A. sollicitans* and in *A. triseriatus*; the latter, however, was caught in much smaller numbers.

TABLE XXVII

NUMERICAL IMPORTANCE OF
VECTORS OF EQUINE ENCEPHALOMYELITIS
BY COLLECTIONS

SPECIES	LARVAE Number	LARVAE %	ADULT Number	ADULT %	Total Collections	Numerical Importance in %
Aedes atropalpus	77	65.3	41	34.7	118	3.6
A. cantator	399	40.0	600	60.0	999	30.6
A. sollicitans	145	15.3	802	84.7	947	29.0
A. taeniorhynchus	17	48.5	18	51.5	35	1.1
A. triseriatus	33	17.3	158	82.7	191	5.9
A. vexans	519	53.3	454	46.7	973	29.8
TOTAL	1,190	36.5	2,073	63.5	3,263	100.0

When the numerical importance of the vectors is evaluated on the number of collections, there is a slight but unimportant rearrangement in this series. In Table XXVII this evaluation is made. A. cantator was

TABLE XXVIII

NUMBER OF SPECIMENS PER COLLECTION
VECTORS OF EQUINE ENCEPHALOMYELITIS

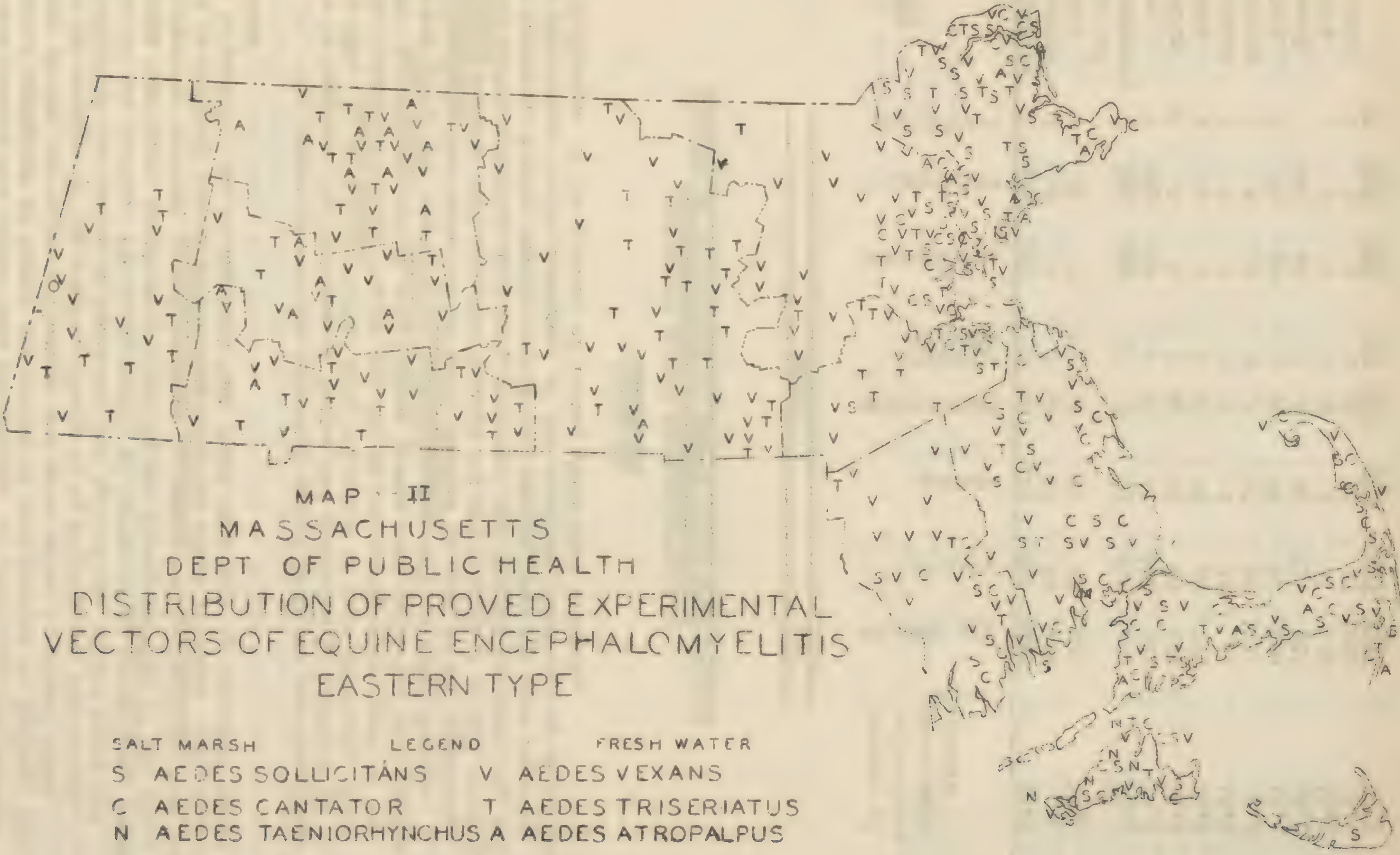
SPECIES	LARVAE	ADULTS
Aedes atropalpus	12.9	1.5
A. cantator	6.8	2.2
A. sollicitans	7.3	3.2
A. taeniorhynchus	6.6	1.1
A. triseriatus	2.8	1.4
A. vexans	6.5	2.3
All vectors	7.0	2.5

collected most often; A. vexans and A. sollicitans were second and third in this series. However, there is no statistical significant difference in either evaluation of the importance of these species, and it may be concluded that these vectors were collected with about the same frequency and are, probably, of about the same numerical importance. In this evaluation, the percent of adult collections is much higher. Whereas only

TABLE XXIX

VECTORS OF EQUINE ENCEPHALOMYELITIS
PERCENT OF COLLECTIONS OF LARVAE WHICH WERE VECTORS

County	Aedes atropalpus	cantator	sollicitans	taeniorhynchus	triseriatus	vexans	vectors	all species	Percent of collections which were vectors
Barnstable	0	184	48	0	0	167	399	2870	13.9
Berkshire	0	0	0	0	2	59	61	4507	1.4
Bristol	0	39	2	0	2	21	64	1931	3.3
Dukes and Nantucket	0	112	70	17	0	30	229	1563	14.7
Essex	3	11	3	0	0	11	28	3711	.75
Franklin	29	0	0	0	2	24	55	2507	2.2
Hampden	35	0	0	0	7	40	82	3193	2.6
Hampshire	10	0	0	0	1	39	50	1543	3.2
Middlesex	0	12	4	0	1	17	34	6278	.5
Norfolk	0	6	3	0	9	7	25	2514	1.0
Plymouth	0	28	14	0	3	60	105	4043	2.6
Suffolk	0	7	1	0	0	2	10	388	2.6
Worcester	0	0	0	0	6	42	48	5935	.8
	77	399	145	17	33	519	1190	40983	2.9



MAP II
MASSACHUSETTS
DEPT OF PUBLIC HEALTH
DISTRIBUTION OF PROVED EXPERIMENTAL
VECTORS OF EQUINE ENCEPHALOMYELITIS
EASTERN TYPE

LEGEND

SALT MARSH	FRESH WATER
S AEDES SOLLICITANS	V AEDES VEXANS
C AEDES CANTATOR	T AEDES TRISERIATUS
N AEDES TAENIORHYNCHUS	A AEDES ATROPALPUS

38.7% of the specimens were adults, 63.5% of the collections were adults. This difference indicates that the average number of specimens per collection was greater for larvae than for adults. In Table XXIX the average number of specimens of larvae and adults of each species is listed. The average of the larvae per collection was seven which is almost three times the average of the adults. There is no significant statistical difference in the number of specimens per collection, either among the adults or the larvae. The large number of larvae of A. atropalpus, however, suggests that large broods were found in one place. Adults of the three more numerous vectors, A. sollicitans, A. vexans and A. cantator, were captured in slightly larger collections than the other vectors. This difference is probably due to the fact that there were more specimens of these species.

The number of vectors collected varied from one section of the state to another. Collections of larvae are tabulated by counties in Table XXX. A. atropalpus larvae were collected in four counties, three in the Connecticut River Valley and one in the northeastern part of the state. A. cantator and A. sollicitans larvae were collected only in the counties along the coast and A. taeniorhynchus only in Dukes County. A. triseriatus was collected in small numbers in most of the counties. A. vexans was the most numerous species and was collected in all counties. Of the larvae collected in Dukes, Nantucket and Barnstable Counties, 81% were vectors. Equine encephalomyelitis, however, has not been reported from this area. In the remainder of the counties, there was no statistical difference in the percent of larvae which were vectors.

TABLE XXX

VECTORS OF EQUINE ENCEPHALOMYELITIS
PERCENT OF COLLECTIONS OF ADULTS WHICH WERE VECTORS

County	Aedes								
	atropalpus	cantator	sollicitans	taenio-rhynchus	triseriatus	vexans	vectors	All species	Percent of collections which were vectors
Barnstable	6	163	196	0	6	126	497	1395	35.6
Berkshire	0	0	0	0	12	12	24	477	.5
Bristol	0	14	7	0	2	35	58	206	28.2
Dukes and Nantucket	0	168	290	17	3	31	509	625	81.4
Essex	2	129	206	0	14	31	382	989	38.7
Franklin	26	0	0	0	33	21	80	424	18.9
Hampden	4	0	0	0	13	23	40	213	18.8
Hampshire	1	0	0	0	9	6	16	85	18.8
Middlesex	1	4	16	0	8	27	56	1217	4.6
Norfolk	0	14	30	0	13	26	83	464	17.9
Plymouth		100	46	1	4	60	211	823	25.2
Suffolk	0	7	10	0	6	8	31	158	19.6
Worcester	1	0	1	0	36	48	86	1024	8.4
	41	599	802	18	159	454	2073	8100	25.6

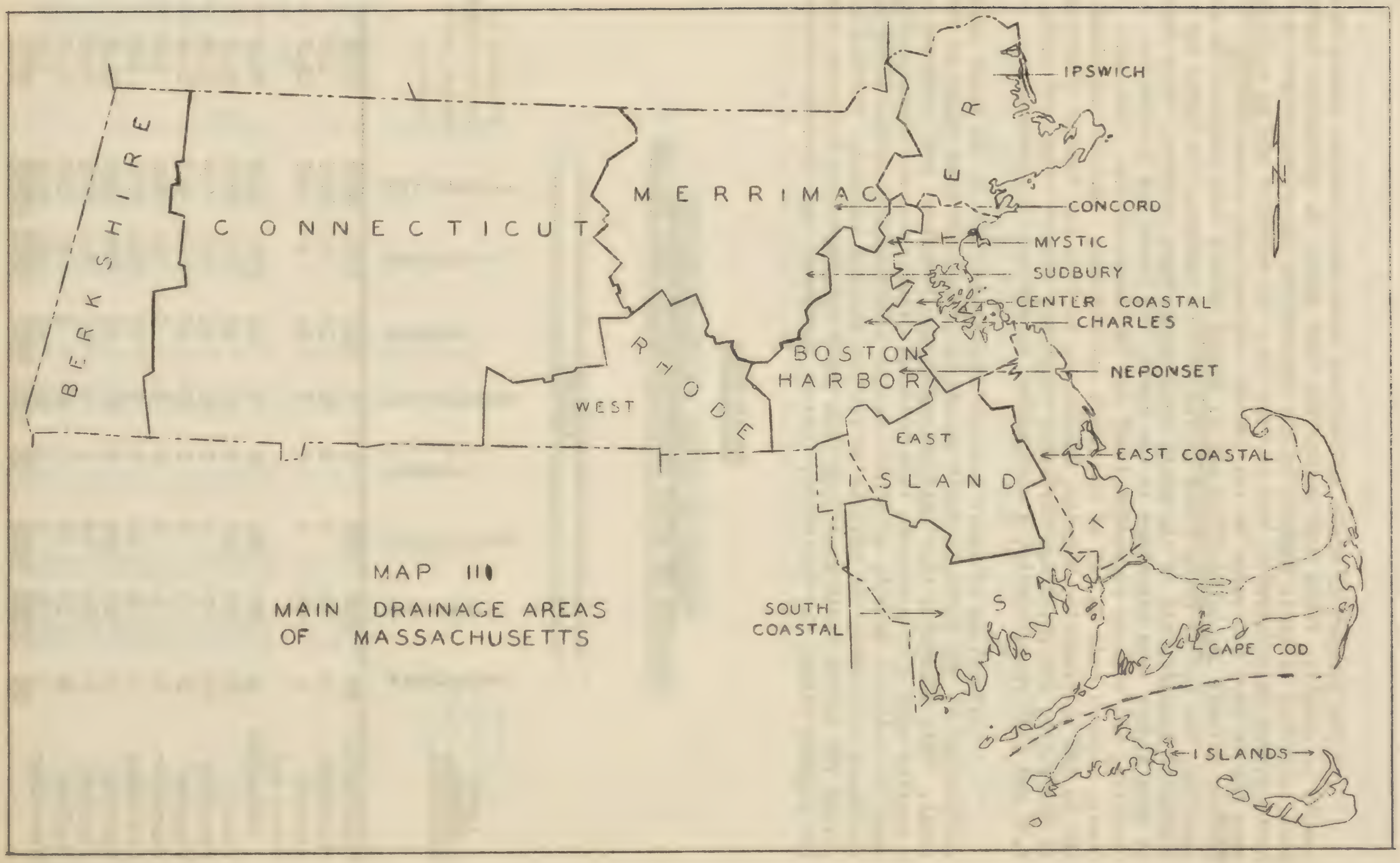
The percent of adult collections which were vectors varied from county to county. Table XXXI summarizes this data. A. atropalpus adults were collected in small numbers in the Connecticut River Valley and in northeastern Massachusetts, and on Cape Cod. A. cantator and A. solliicitans adults were collected in the coastal regions and, occasionally, further inland. A. triseriatus and A. vexans adults were captured in all counties, the latter being found in far greater numbers. In Dukes and Nantucket Counties 81% of the adult collections were vectors. This figure is much higher than elsewhere in the state. In Essex and Barnstable Counties, the vectors represented 39% and 36% respectively. Bristol County vectors made up 28% of the adult collections. Vectors comprised 18% to 19% in Franklin, Hampden, Hampshire, Norfolk and Suffolk Counties. In Berkshire, Middlesex and Worcester Counties, vectors comprised 0.5%, 4.6% and 8.4% respectively, a statistical significant difference.

Collections of adult vectors comprised 25.6% of the total adult collections in the Survey. Adult specimens of vectors were 22.1% of the total. This indicates that collections of adult vectors were composed of a smaller number of specimens than those of other species. Consequently, when the relative density of adult vectors is determined on the basis of specimens collected, the percent of vectors becomes smaller. Vectors comprised 76% of the adult specimens from Dukes and Nantucket Counties, again the highest figure for the state. Essex, Barnstable and Norfolk vectors

TABLE XXXI

VECTORS OF EQUINE ENCEPHALOMYELITIS
PERCENT OF ADULT SPECIMENS WHICH WERE VECTORS

ADULT SPECIMENS	Aedes								Percent of collections which were vectors
	atropalpus	cantator	sollicitans	taenio-rhynchus	triseriatus	vexans	vectors	All species	
Barnstable	12	439	823	0	7	413	1694	6089	27.8
Berkshire	0	0	0	0	39	15	54	1395	3.9
Bristol	0	33	8	0	2	54	97	638	15.2
Dukes and Nantucket	0	367	730	19	3	61	1180	1549	76.2
Essex	2	206	648	0	15	48	919	3016	30.5
Franklin	35	0	0	0	40	35	110	616	17.9
Hampden	5	0	0	0	19	47	71	407	17.4
Hampshire	4	0	0	0	9	7	20	209	9.6
Middlesex	1	6	82	0	9	95	193	3272	5.9
Norfolk	0	86	136	0	21	46	289	1339	21.6
Plymouth	0	175	86	1	4	134	400	2476	16.2
Suffolk	0	14	34	0	10	9	67	583	11.5
Worcester	1	0	1	0	50	88	140	2130	6.6
	60	1326	2548	20	228	1052	5234	23710	22.1



MAP III

MAIN DRAINAGE AREAS
OF MASSACHUSETTS

ranged from 30% to 21%. Bristol, Franklin, Hampden, Plymouth and Suffolk Counties ranged from 20% to 11%. In Berkshire, Hampshire, Middlesex and Worcester Counties, vectors comprised less than 10% of the adult specimens.

Biting Habits Table XX listed the adult mosquitoes captured on man. The vectors were represented as follows:

	PERCENT	NUMBER
Aedes sollicitans	37.3	738
A. cantator	15.7	311
A. vexans	6.0	120
A. taeniorhynchus	0.7	12
A. triseriatus	0.2	3
A. atropalpus	0.0	0
	59.9%	1184

Table XXI lists the adult mosquitoes caught in houses. Here the vectors were represented as follows:

	PERCENT	NUMBER
Aedes cantator	1.8	56
A. sollicitans	1.8	56
A. vexans	1.4	44
A. triseriatus	0.6	19
A. atropalpus	0.4	12
A. taeniorhynchus	0.0	0
	6.0%	187

Of the 1977 adults captured on man, 1184 or 59.9% were vectors. Of the 3130 adults caught in houses only 187 or 6.0% were vectors. It had already been pointed out that the vast majority of the mosquitoes captured on man were collected outdoors. Therefore, it is at once apparent that the chances of a vector biting man are about ten times as great outdoors as indoors. This information is important in protecting animals and man from unnecessary exposure to vectors during outbreaks of the disease. Measures should be directed toward the removal of horses and mules from pastures and into screened stables. Children and infants, as well as adults, should be kept behind screens as much as possible and not permitted to remain unprotected when outdoors where mosquitoes are prevalent.

Unfortunately, the collections of mosquitoes on animals were so small that they are of no value. The two hundred eleven specimens which were captured in barns and stables may be an indication of the attraction of the vectors to horses and cattle. There were 33 vectors captured in barns; these were A. vexans 18, A. cantator 14, A. sollicitans 1, forming 8.5%, 6.6%, 0.5% of all mosquitoes captured in these buildings. These numbers are too small to be conclusive. If the situation is analogous to man, then we may assume that whereas only 15.5% of the mosquitoes captured in barns and stables were vectors, the vectors comprise a much larger percent of the mosquitoes which bite animals outdoors.

Distribution by Watersheds The distribution of vectors according to watersheds has been determined by punch card analysis. The watersheds are noted on Map III. Towns had to be considered as units and were placed into that watershed into which most of the town drained. This distribution is listed

TABLE XXXII

VECTORS OF EQUINE ENCEPHALOMYELITIS
DISTRIBUTION OF DRAINAGE AREAS
NUMBER OF COLLECTIONS *

DRAINAGE AREA	Aedes atropalpus	Aedes cantator	Aedes sollicitans	Aedes taenio-rhynchus	Aedes triseriatus	Aedes vexans	All Vectors
Salt Water							
Cape Cod	6	297	264	0	5	294	866
Cent.Coastal	9	46	70	0	8	19	152
East Coastal	0	21	19	0	1	31	72
Ipswich	12	121	245	0	14	42	434
Islands	0	267	367	37	3	68	742
So.Coastal	0	147	43	1	5	110	306
	27	899	1008	38	36	564	2572
Boston Harbor	0	0	0	0	28	44	72
Merrimac	0	0	0	0	19	69	88
Rhode Island							
West	1	0	0	0	17	56	74
East	0	12	9	0	5	44	70
Total	1	12	9	0	22	100	144
Connecticut	117	0	0	0	77	335	529
Berkshire	0	0	0	0	14	86	100
Grand Total	145	911	1017	38	196	1198	3505

* Interpolated from punch card analysis.

in Table XXXII. The highest numbers of vectors were collected in the "Islands" and "Cape Cod" watersheds. Because three of the vectors are salt marsh mosquitoes, it is only natural that the coastal salt water areas, as a whole, have more vectors than other watersheds. The "Berkshire" and "Merrimac" watersheds have a low percent of vectors, although mosquitoes are not significantly less prevalent.

CHAPTER XIV

VECTORS OF MALARIA

Numerical Importance All of the *Anopheles* of Massachusetts may act as vectors of malaria. However, *A. quadrimaculatus* is the only important one. *A. maculipennis* may transmit the plasmodia with greater effectiveness than *A. punctipennis*, but the latter is much more numerous and hence may play a greater role. *A. crucians* and *A. walkeri* are rare and hence are of no importance. The collection data on these vectors is summarized in Table XXXIII. The *Anopheles* comprised 19.3% of the total

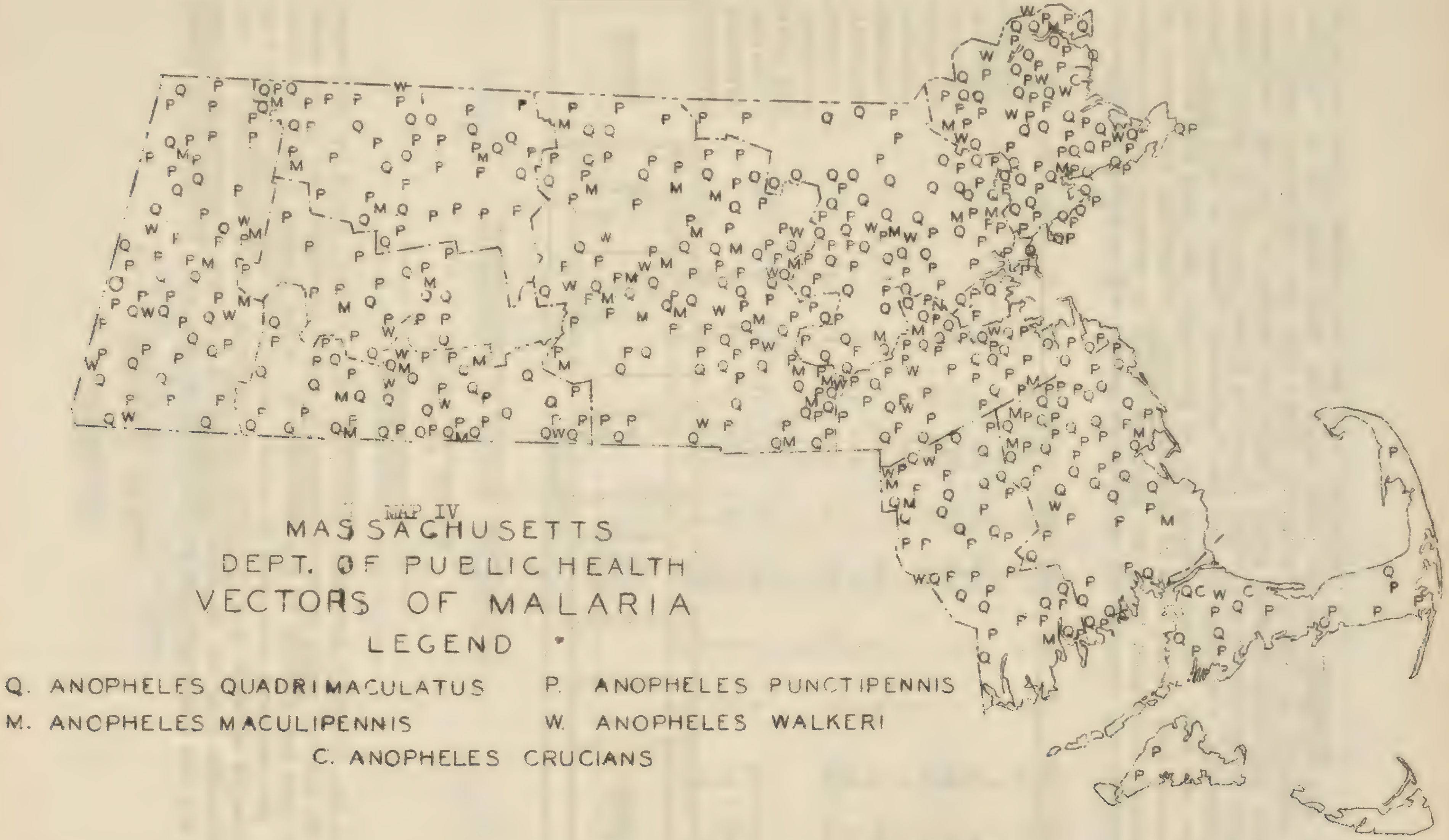
TABLE XXXIII

VECTORS OF MALARIA

DISTRIBUTION OF SPECIES AND COUNTIES

County	ANOPHELES											
	crucians		maculipennis		punctipennis		quadrimaculatus		walkeri		Total	
	A	L	A	L	A	L	A	L	A	L	A	L
Barnstable		5	0	0	2	41	4	21	1		7	67
Berkshire			0	11	42	830	29	57	1	8	72	906
Bristol			1	2	12	244	11	152	1	2	25	400
Dukes and Nantucket			0	0	0	5	0	0	0			5
Essex		1	2	1	15	292	60	619	12	6	89	919
Franklin				4	16	544	2	22	0	1	18	577
Hampden				5	21	1343	4	189	0	4	25	1541
Hampshire				2	3	146	5	9		1	8	158
Middlesex				4	22	448	14	178		3	36	632
Norfolk				2	2	29	20	117	2	2	24	250
Plymouth		1		5	5	392	14	241	4		23	640
Suffolk					2	3	1	2			3	5
Worcester			2	21	50	1341	18	116	7	4	77	1482
TOTAL	0	7	5	58	192	5757	182	1729	28	31	407	7989

collections; 22.1% of the larvae and 9.4% of the adults. The largest numbers of collections of *Anopheles*, 1541 and 1482, were made, respectively, in Hampden and Worcester. Since Worcester is much larger than Hampden, the *Anopheles* were more prevalent in the latter county. Very few collections were made in Dukes, Nantucket, and Suffolk Counties. The small number found in Suffolk County is easily explained because this county comprises the City of Boston and several other densely populated communities where mosquitoes are less likely to breed. Dukes and Nantucket Counties, on the other hand, are quite rural and why *Anopheles* were collected in such small numbers has not been explained.


MAP IV
MASSACHUSETTS
DEPT. OF PUBLIC HEALTH
VECTORS OF MALARIA
LEGEND
Q. ANOPHELES QUADRIMACULATUS
P. ANOPHELES PUNCTIPENNIS
M. ANOPHELES MACULIPENNIS
W. ANOPHELES WALKERI
C. ANOPHELES CRUCIANS

Biting Habits *Anopheles* were rarely captured on man outdoors. There were only 7 *A. punctipennis* and 2 *A. quadrimaculatus* among a total of 1977 mosquitoes captured on man. It seems that these species are not serious offenders in the open. Of 3130 mosquitoes captured in houses, *A. quadrimaculatus* comprised 13.0%, *A. punctipennis* 1.5%, *A. maculipennis* 0.9% and *A. walkeri* 0.7%, a total of 16.1%. *Anopheles* apparently prefer to bite man indoors. This observation may be contrasted with the *Aedes* vectors of equine encephalomyelitis where the situation is reversed. Of a total of 211 mosquitoes captured in barns and stables, 7 specimens (3.3%)

TABLE XXXIV

VECTORS OF MALARIA
DISTRIBUTION IN DRAINAGE AREAS
BY COLLECTIONS*

	ANOPHELES					
Watershed	crucians	maculipennis	punctipennis	quadri-maculatus	walkeri	Total
Salt Water						
Cape Cod	5	1	46	5	1	58
Central Coast	0	1	79	145	0	226
East Coast	1	1	146	152	0	300
Ipswich	1	2	331	535	30	899
Islands		1	5	0	0	6
South Coast		1	196	132	1	330
TOTAL	7	7	1003	970	32	2019
Boston Harbor	0	5	293	202	6	505
Merrimac	0	7	803	232	9	1051
Rhode Island						
West	0	3	427	53	5	488
East	0	8	354	202	14	578
TOTAL	0	11	781	255	19	1066
Connecticut	0	28	2732	303	13	3076
Berkshire	0	7	704	81	9	801
GRAND TOTAL	7	65	6316	2043	88	8519

* Interpolated from punch card analysis.

were *Anopheles*. Collections of mosquitoes on animals were not attempted. It is, therefore, impossible to say that Anopheles are not attracted to

animals, but the larger proportion of specimens captured in houses indicate that *Anopheles* prefer to bite man. The detailed analysis of each species of *Anopheles* is included in Chapter XV.

Distribution by Drainage Areas The most noteworthy observation in this distribution is the fact that *Anopheles* are more numerous along large rivers. The main Connecticut River Valley is the best illustration of this distribution. Collections were most numerous in towns adjacent to the river, and least numerous in towns furthest from it. This peculiar distribution is due to the breeding habits of this genus since it prefers the rivers and streams to all other places. (See Table X, page 66) The distribution of *Anopheles* by drainage areas is summarized in Table XXXIV.

CHAPTER XV

MOSQUITOES OF MASSACHUSETTS

Genera The order of Diptera is subdivided into a number of families; the particular family of flies to which all mosquitoes belong is termed Culicidae. This family is composed of two subfamilies, the Culicinae and the Chaoborinae. The members of the first subfamily are readily distinguished from the other by the presence in the female of a conspicuous proboscis adapted for bloodsucking. The Culicinae, or biting mosquitoes, are divided into two tribes, the Anophelini and the Culicini. The tribes, in turn, are divided into genera, and genera into species. The tribe, Anophelini, contains only one genus, the Anopheles. All the other genera of biting mosquitoes belong to the tribe, Culicini. The name of a mosquito, as it is generally used, consists of the name of the genus and that of the species.

TABLE XXXV

RELATIVE IMPORTANCE OF THE GENERA OF MASSACHUSETTS MOSQUITOES

PERCENT OF ADULTS AND LARVAE BY SPECIMENS

Genus	Larvae		Adults		Total Speci-mens	Relative Importance by %
	Number	%	Number	%		
Aedes	9,944	54.7	8,221	45.3	18,165	6.5
Anopheles	31,690	96.2	1,250	3.8	32,940	11.8
Culex	208,099	86.5	7,546	3.5	215,645	77.4
Mansonia	662	9.1	6,663	90.9	7,327	2.6
Psorophora	5	55.6	4	44.4	9	0.0
Theobaldia	2,022	96.0	85	4.0	2,107	0.8
Uranotaenia	2,318	99.2	19	0.8	2,337	0.8
Wyeomyia	16	64.0	9	36.0	25	0.0
Orthopodomyia	3	10.0	0	0.0	3	0.0
	254,759	91.45	23,797	8.55	278,558	99.9

There are nine genera of Culicinae in Massachusetts. The genus Anopheles represents the tribe, Anophelini. The genera Aedes, Culex, Mansonia, Psorophora, Theobaldia, Uranotaenia and Wyeomyia belong to the tribe, Culicini. The relative numerical importance of these genera as determined by the Survey is determined by two methods. Table XXXV lists the genera and the relative numerical percent of the total mosquito fauna in Massachusetts. This percent distribution is calculated on the basis of the specimens collected. In this evaluation the genus Culex represents 77.4% of the mosquitoes, the genus Anopheles 11.8% and the genus Aedes only 6.5%.

The genera are broken down further into the number of larvae and adults collected, and the proportion of each to the total of the

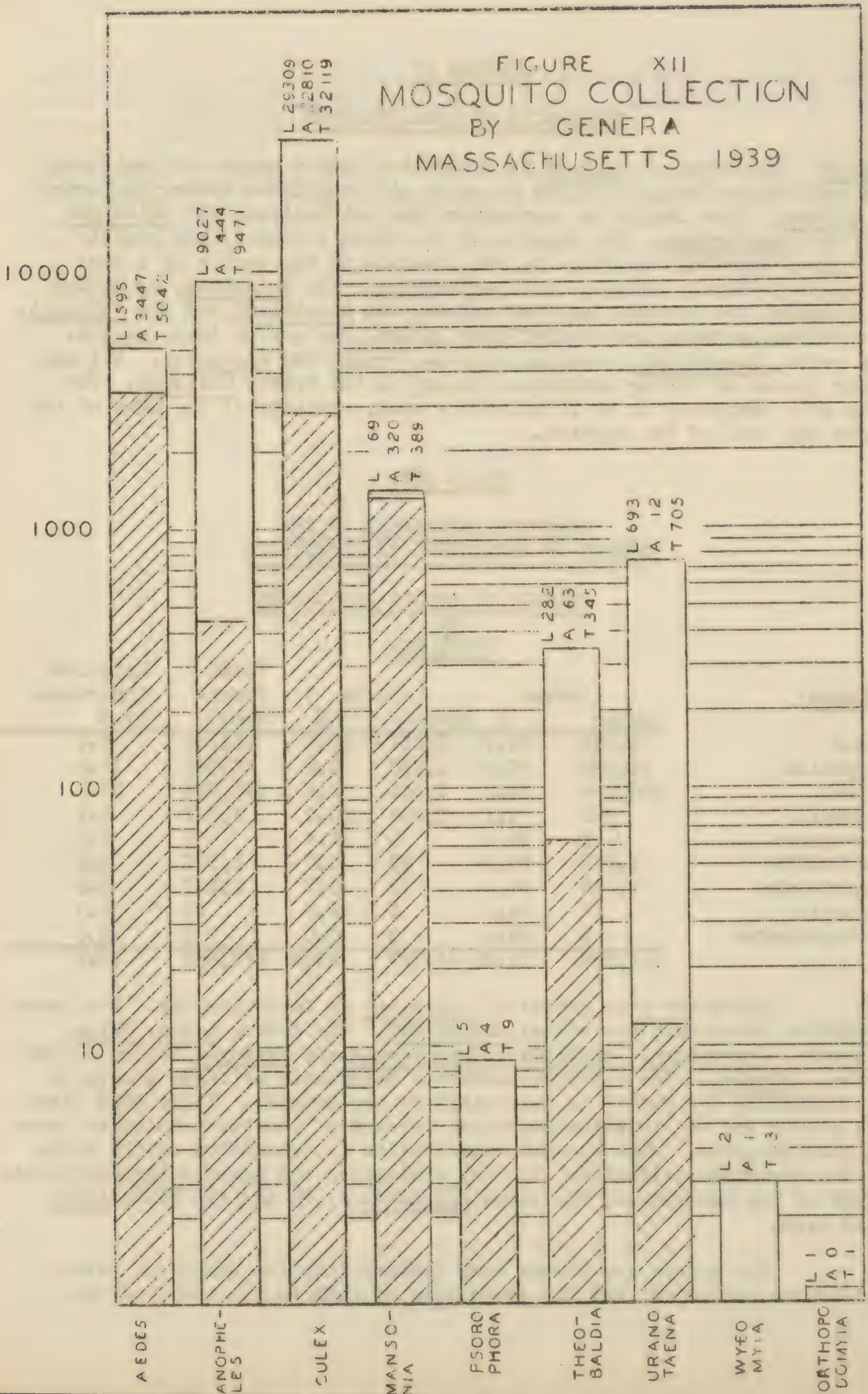


FIGURE XII
MOSQUITO COLLECTION
BY GENERA
MASSACHUSETTS 1939
10000
1000
100
10
L 1595
A 3447
T 5042
L 9027
A 444
T 9471
L 29309
A 2810
T 32119
L 69
A 320
T 389
L 5
A 4
T 9
L 282
A 63
T 345
L 693
A 12
T 705
L 2
A 1
T 3
L 1
A 0
T 1
AEDES
ANOPHE- LES
CULEX
MANSO- NIA
PSORO PHORA
THEO- BALDIA
URANO TAENA
WYEO MYIA
ORTHOPO DOMYIA

genus is expressed as a percent. Among the specimens of *Anopheles* and *Culex*, larvae represented the vast majority. Among *Aedes*, however, adult specimens comprised almost a half of the total. The other genera were collected in much smaller numbers. *Mansonia* larvae, because of their peculiar adaptation in attaching themselves to plants, were collected very infrequently.

When the relative numerical importance of the genera is determined on the basis of the number of collections, another set of figures is obtained. *Culex* form 65.4%, *Anopheles* 19.3%, and *Aedes* 10.8% of the total collections. Although the percent of each is changed, the genera remain in the same order of numerical importance. These evaluations are made in Table XXXVI and charted in Figure XII.

TABLE XXXVI

RELATIVE IMPORTANCE OF THE GENERA OF MASSACHUSETTS MOSQUITOES

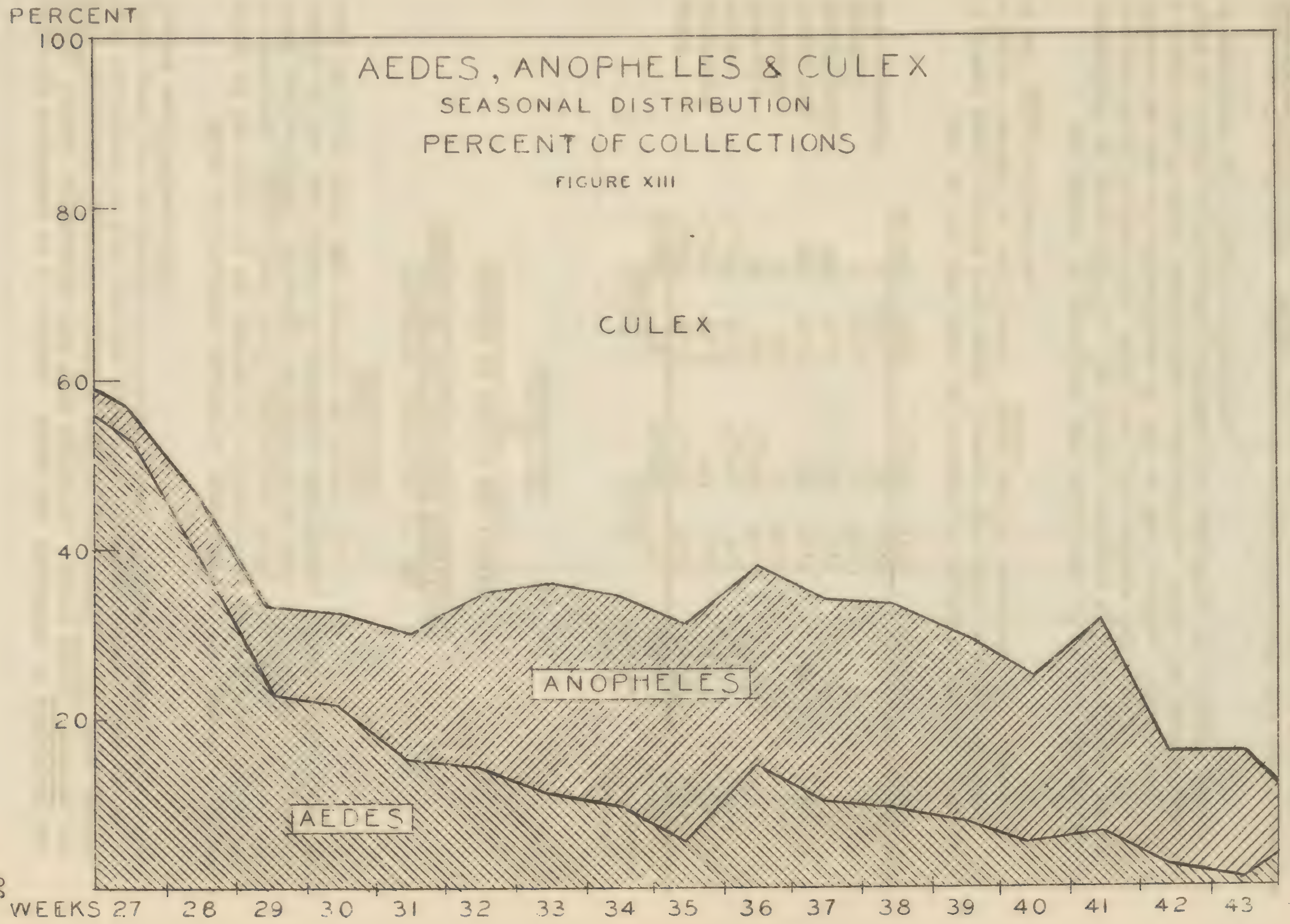
PERCENT OF ADULTS AND LARVAE BY COLLECTIONS

	Larvae		Adults		Total Specimens	Relative Importance
	Number	%	Number	%		By %
Aedes	1,595	31.7	3,447	68.3	5,042	10.8
Anopheles	9,027	95.3	444	4.7	9,471	19.3
Culex	29,309	91.3	2,810	8.7	32,119	65.4
Mansonia	69	5.0	1,320	95.0	1,389	2.7
Psorophora	5	5.5	4	45.0	9	0.0
Theobaldia	282	81.7	63	18.3	345	0.6
Uranotaenia	693	98.3	12	1.7	705	1.3
Wyeomyia	2	67.0	1	63.0	3	0.0
Orthopodomyia	1	100	0	0.0	1	0.0
	40,983	83.5	8,101	17.5	49,084	100.1

Due to the fact that the number of specimens per collection is lower among adults than among larvae, the adult collections form a larger percent of each genus. *Aedes* adults represent 68.3 percent of all *Aedes* collection.

The number of specimens per collection of adults and larvae is summarized in Table XXXVII. The larvae averaged 6.20 specimens per collection which is more than twice the 2.94 average for adults. This difference in size of collections is due to two factors. The capture of a single adult often constituted a collection, while the larvae usually found in larger aggregates, afforded the gathering of a larger number of specimens in a single collection.

Seasonal Distribution *Aedes* mosquito collections were the most numerous when the Survey began in July. Thereafter, they continued to decrease as the season progressed. *Aedes* comprised over 50% of all collections early in July, and less than 2% late in August. *Anopheles* were most



AEDES, ANOPHELES & CULEX
SEASONAL DISTRIBUTION
PERCENT OF COLLECTIONS
FIGURE XIII

prevalent between the 31st and the 42nd week, that is, during August, September and early October when this genus comprised 20-25% of the collections. Culex continued to increase with the progress of the season, beginning with an initial 43% in July and ending with 84% in August. The seasonal curves are plotted in Figure XIII and the percent of the three genera is given in the associated table.

TABLE XXXVII

AVERAGE NUMBER OF SPECIMENS PER COLLECTION

	LARVAE	ADULTS
Aedes	6.23	2.38
Anopheles	3.51	2.81
Culex	9.50	2.69
Mansonia	9.59	5.05
Psorophora	1.0	1.0
Theobaldia	7.17	1.35
Uranotaenia	3.34	1.6
Wyeomyia	8.0	9.0
Orthopodomyia	3.0	0
All genera	6.20	2.94

Species There are fifty-six species of mosquitoes in Massachusetts; forty-one of these belong to the Culicinae or biting mosquitoes. During the Survey, four Culicinae and two Chaoborinae were collected in Massachusetts for the first time. Three species previously collected in the state were not included in the Survey's findings. The total collections as well as the number of specimens of adults and larvae is summarized in Table XXXVIII.

Those species which are of special public health importance have been discussed separately in Chapter XIII, Vectors of Equine Encephalomyelitis, and Chapter XIV, Vectors of Malaria. Data on each species of Culicinae is analyzed in three main categories:

1. Geographical Distribution
2. Seasonal Distribution
3. Public Health Importance

The first four portions of this analysis are presented in a series of compact tables which give the most complete presentation of the data. The public health importance of each species is discussed separately.

Table XXXIX is the presentation of data on the geographical distribution of the Culicinae. The figures indicate the number of collections made during the duration of the Survey. Under each species the adults and larvae are considered separately. Dukes and Nantucket Counties are combined; these two counties are islands off the south coast of Cape Cod, are small in size and have similar characteristics.

The seasonal distribution of the species is presented in Table XL and XLI. The former is confinded to larvae and consists of two parts. In part A, the actual number of collections of larvae is noted. Collections from the 27th week (July 1st) through the 43rd week (October 31st) are included as these represent state-wide coverage. The adult collections are analyzed similarly in Table XLI.

TABLE XXXVIII

MOSQUITOES OF MASSACHUSETTS

	ADULTS		LARVAE	
	No. of Specimens	No. of Collections	No. of Specimens	No. of Collections
Subfamily Culicinae				
Aedes atropalpus	60	41	993	77
A.aurifer	542	186	0	0
A.canadensis	770	301	495	122
A.cantator	1326	599	2704	399
A.cinereus	471	256	482	121
A.communis*	0	0	0	0
A.dorsalis	4	4	79	14
A.excrucians	485	268	41	15
A.fitchii	196	95	21	5
A.hirsuteron	7	4	4	4
A.implacabilis	29	16	10	3
A.impiger*	0	0	0	0
A.intrudens	295	131	48	8
A.punctor	6	5	0	0
A.sollicitans	2548	802	1054	145
A.stimulans	59	38	8	2
A.taeniorhynchus	20	18	112	17
A.trichurus	20	8	2	2
A.triseriatus	228	159	92	33
A.trivittatus	6	3	1	1
A.vexans	1052	454	3358	519
Anopheles crucians**	0	0	20	7
A.maculipennis	30	5	113	58
A.punctipennis	300	192	20396	5757
A.quadrimaculatus	790	182	6810	1729
A.walkeri	57	28	84	31
Culex apicalis	1746	688	78944	13051
C.pipiens	3880	1313	103138	11640
C.salinarius	832	339	2215	922
C.territans	943	398	23353	3527
Mansonia perturbans	6665	1320	662	69
Orthopodomyia signifera**	0	0	3	1
Psorophora ciliata	4	4	2	2
P.columbiae**	0	0	3	3
P.posticata*	0	0	0	0
Theobaldia impatiens**	2	2	0	0
T.inornata	6	3	0	0
T.melanura	70	52	1971	265
T.morsitans	7	6	51	17
Uranotaenia sapphirina	19	12	2318	693
Wyeomyia smithii	9	1	16	2
Subfamily Chaoborinae*				
Chaoborus (not routinely identified)	41	16	37	20
C.albatus				
Chaoborus albipes	0	0	5	2
C.americanus				

TABLE XXXVIII
(continued)
MOSQUITOES OF MASSACHUSETTS

	ADULTS		LARVAE	
	No. of Specimens	No. of Collections	No. of Specimens	No. of Collections
Subfamily Chaoborinae***				
C.punctipennis				
C.trivittatus				
Corethrella brakeleyi**	0	0	14	5
Dixa (not routinely identified)	11	6	195	84
D.centralis				
D.clavata				
D.cornuta				
D.modesta				
D.notata				
Eucorethra underwoodi**	0	0	3	3
Mochlonyx (not routinely identified)	0	0	24	11
M.cinctipes				
M.fuliginosus				
M.karnerensis				

* Not collected by Survey
** Recorded by Survey for the first time in Massachusetts
*** Species not routinely identified by Survey

Detailed analysis of the data collected on larvae was presented in Chapter XI, "Mosquito Breeding Places". The adults were similarly treated in Chapter XII, "The Collection of Adult Mosquitoes". One other analysis on both larvae and adults is added here because it applies to both stages of the mosquito. Table XLII A and Table XLII B summarize the data on the collection of larvae and adults, respectively, in relation to the density of population within, in one hundred yard radius of the collection point. This data is that gathered from collections made at regular collection points. In general, it may be concluded that mosquitoes were collected with greater frequency in less densely populated areas. This observation is explained by three factors:

1. Less densely populated areas are more numerous than densely populated places.
2. The more densely populated the area, the more paving there and the breeding of mosquitoes is greatly diminished.
3. Collectors were more likely to look for collection points in rural areas rather than in urban areas as the former are more accessible and more productive.

There is no significant difference between the number of adult mosquitoes and larvae that were collected in each of the different categories of population density.

TABLE XXXIX

MOSQUITOES OF MASSACHUSETTS BY COUNTIES

County	AEDES													
	atropalpus		aurifer		canadensis		cantator		cinereus		dorsalis		excrucians	
	A	L	A	L	A	L	A	L	A	L	A	L	A	L
Barnstable	6	-	64	-	92	21	163	184	41	50	2	10	87	3
Berkshire	-	-	3	-	4	3	-	-	9	3	-	-	1	-
Bristol	-	-	5	-	5	7	14	39	13	-	-	-	1	1
Dukes *	-	-	1	-	8	3	168	112	10	17	-	1	4	-
Essex	2	3	10	-	23	2	129	11	39	1	-	1	42	-
Franklin	26	29	1	-	8	1	-	-	2	-	-	1	2	-
Hampden	4	35	5	-	15	2	1	-	6	-	-	-	7	1
Hampshire	1	10	4	-	2	-	-	-	3	-	-	-	4	1
Middlesex	1	-	12	-	14	2	4	12	20	4	-	-	24	1
Norfolk	-	-	10	-	26	73	14	6	15	20	1	-	23	5
Plymouth	-	-	63	-	57	6	100	28	28	8	1	1	37	2
Suffolk	-	-	1	-	1	1	7	7	33	1	-	-	1	-
Worcester	1	-	7	-	46	1	-	-	37	13	-	-	36	1
TOTAL	41	77	186	0	301	122	600	399	256	117	4	14	269	15

* Includes Nantucket

County	ANOPHELES										CULEX			
	crucians		maculipennis		punctipennis		quadrimaculatus		walkeri		apicalis		pipiens	
	A	L	A	L	A	L	A	L	A	L	A	L	A	L
Barnstable	-	5	-	-	2	41	4	21	1	-	17	1542	44	353
Berkshire	-	-	-	11	42	830	29	57	1	8	61	1013	143	1087
Bristol	-	-	1	2	12	244	11	152	1	2	12	577	33	568
Dukes *	-	-	-	-	-	5	-	-	-	-	7	393	26	470
Essex	-	1	2	1	15	292	60	619	12	6	24	654	63	1435
Franklin	-	-	-	4	16	544	2	28	-	1	68	601	139	794
Hampden	-	-	-	5	21	1343	4	189	-	4	8	821	33	325
Hampshire	-	-	-	2	3	146	5	9	-	1	6	540	13	464
Middlesex	-	-	-	4	22	447	14	178	-	3	347	1536	391	3188
Norfolk	-	-	-	2	2	129	20	117	2	2	4	404	69	1230
Plymouth	-	1	-	6	5	392	14	241	4	-	38	2203	50	515
Suffolk	-	-	-	-	2	3	1	2	-	-	5	8	61	340
Worcester	-	-	2	21	50	1341	18	116	7	4	91	2759	248	871
TOTAL	0	7	5	58	192	5757	182	1729	28	31	688	13051	1313	11640

* Includes Nantucket

A Adults

L Larvae

Number indicates collections

TABLE XXXIX

MOSQUITOES OF MASSACHUSETTS BY COUNTIES

AEDES																							
fitchii		hirsuteron		implacabilis		intrudens		punctor		sollicitans		stimulans		taeniorhynchus		trichurus		triseriatus		trivittatus		vexans	
A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L
58	5	2	1	7	-	51	3	4	-	196	48	19	2	-	-	6	-	5	-	1	-	126	167
2	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	12	2	-	-	12	59
-	-	-	-	-	-	-	-	-	-	7	2	-	-	-	-	-	-	2	2	-	-	35	21
2	-	-	2	-	-	1	-	-	-	290	70	1	-	7	17	-	-	3	-	-	-	31	30
12	-	-	-	1	1	11	-	-	-	260	3	5	-	-	-	-	-	14	-	-	-	31	11
1	-	-	-	-	-	2	2	-	-	-	-	1	-	-	-	-	-	33	2	-	1	21	24
1	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	1	13	7	-	-	23	40
1	-	-	-	-	-	3	-	-	-	-	-	1	-	-	-	-	-	9	1	-	-	6	39
3	-	1	-	-	-	7	-	-	-	16	4	1	-	-	-	-	-	8	1	-	-	27	17
4	-	1	1	1	-	8	1	-	-	30	4	-	-	-	-	-	-	13	9	-	-	26	7
9	-	-	-	1	-	22	-	1	-	46	14	4	-	1	-	1	1	4	3	1	-	60	60
-	-	-	-	-	1	2	-	-	-	10	1	1	-	-	-	-	-	6	-	-	-	8	2
2	-	-	-	6	1	18	2	-	-	1	-	4	-	-	-	1	-	36	6	1	-	48	42
95	5	4	4	16	3	131	8	5	-	856	146	38	2	8	17	8	2	158	33	3	1	454	519

MANSONIA						PSOROPHORA				THEOBALDIA								URANOTAENIA		WYEOMYIA	
salinarius		territans		perturbans		ciliata		columbiae		impatiens		inornata		melanura		morsitans		sapphirina		smithii	
A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L	A	L
24	92	6	80	337	61	-	-	-	-	-	-	-	-	5	99	-	4	1	49	-	2
31	32	76	1168	34	-	-	-	-	-	-	-	-	-	-	-	1	-	1	39	1	-
19	75	6	98	25	-	-	-	-	-	-	-	-	-	-	10	-	-	-	42	-	-
12	251	10	101	31	-	1	-	-	-	-	-	-	-	1	71	-	2	-	1	-	-
22	137	29	409	209	-	-	-	-	-	1	-	-	-	5	1	3	1	-	55	-	-
36	38	31	295	11	-	1	-	-	-	-	-	-	-	4	1	-	-	-	3	-	-
2	7	9	130	49	1	2	-	-	1	-	-	-	-	2	4	-	-	-	60	-	-
3	5	7	236	12	-	-	2	-	2	-	-	1	-	-	-	-	-	-	30	-	-
96	105	103	476	71	-	-	-	-	-	-	-	-	-	8	5	-	6	5	120	-	-
12	79	25	271	146	4	-	-	-	-	-	-	-	-	5	12	-	1	-	64	-	-
12	57	9	54	224	1	-	-	-	-	-	-	-	-	7	50	2	2	2	173	-	-
12	7	15	8	18	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-
58	37	72	198	153	2	-	-	-	-	1	-	2	-	14	11	-	1	3	57	-	-
339	922	398	3524	1320	69	4	2	-	3	2	-	3	-	52	265	6	17	12	693	1	2

TABLE XL A

SEASONAL DISTRIBUTION BY WEEKS

Number of Collections

Larvae

Week of Year	27	28	29	30	31	32	33
Total Collections	296	512	394	515	460	553	585
Aedes atropalpus	0	2	4	0	6	6	9
A. aurifer	0	0	0	0	0	0	0
A. canadensis	4	0	1	2	1	4	0
A. cantator	16	3	16	20	16	5	15
A. cinereus	8	2	1	2	2	4	0
A. dorsalis	1	0	0	1	1	1	9
A. excrucians	0	0	0	1	1	0	0
A. fitchii	1	0	0	0	0	0	1
A. hirsuteron	0	0	0	0	0	0	0
A. implacabilis	0	0	0	0	0	1	1
A. intrudens	0	0	1	0	0	3	0
A. punctor	0	0	0	0	0	0	0
A. sollicitans	2	0	12	12	9	2	1
A. stimulans	0	0	0	0	0	0	0
A. taeniorhynchus	0	0	1	0	0	0	0
A. trichurus	0	0	0	0	0	0	0
A. triseriatus	1	0	4	1	0	9	6
A. trivittatus	0	0	0	0	0	0	0
A. vexans	17	6	18	4	13	60	24
Anopheles crucians	0	0	0	0	0	0	0
A. maculipennis	0	0	1	1	4	6	7
A. punctipennis	12	37	78	106	84	260	347
A. quadrimaculatus	4	2	4	4	27	58	132
A. walkeri	0	0	0	0	2	9	3
Culex apicalis	92	208	396	480	656	824	930
C. pipiens	47	72	146	195	313	465	451
C. salinarius	7	11	22	11	22	31	20
C. territans	29	47	88	120	150	165	193
Mansonia perturbans	1	3	0	1	4	2	2
Psorophora ciliata	0	0	0	0	0	0	1
P. columbiae	0	0	1	0	0	0	0
Theobaldia impatiens	0	0	0	0	0	0	0
T. inornata	0	0	0	0	0	0	0
T. melanura	2	1	5	13	19	14	13
T. morsitans	1	2	1	0	1	0	0
Uranotaenia sapphirina	0	12	30	39	66	105	102
Wyeomyia smithii	0	0	0	0	0	0	0

TABLE XL A

SEASONAL DISTRIBUTION BY WEEKS

Number of Collections

Larvae

34	35	36	37	38	39	40	41	42	43
548	353	381	588	902	839	608	365	126	42
9	9	10	12	5	5	5	4	0	0
0	0	0	0	0	0	0	0	0	0
3	0	8	4	0	3	1	8	3	0
18	14	93	73	42	22	13	5	7	3
2	6	43	12	5	4	2	1	0	0
0	0	0	0	3	0	0	0	0	0
2	1	1	0	0	0	1	0	1	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	1	1	0	0	1	0	0	0	0
0	1	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
21	5	46	18	7	1	0	2	1	1
0	0	0	1	0	0	0	0	0	0
8	0	7	0	0	0	0	1	0	0
0	1	1	0	0	0	0	0	0	0
4	3	0	1	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0
89	35	220	58	12	2	17	19	4	0
0	0	1	0	0	3	0	1	0	0
8	4	10	6	4	3	3	1	0	0
446	577	577	683	742	677	659	378	171	32
172	188	226	224	244	256	197	114	19	5
3	3	0	3	5	1	1	3	1	1
1095	1314	1245	1307	1265	1140	1164	631	339	51
659	853	913	1067	1225	1526	1702	983	672	246
24	33	47	90	70	126	169	86	62	27
286	259	214	286	323	477	509	230	220	41
4	0	0	1	0	2	3	12	15	22
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
11	14	12	10	13	32	56	22	27	9
0	0	1	3	0	1	1	0	0	0
84	84	75	82	43	16	18	2	1	0
0	0	1	0	0	0	0	0	0	1

TABLE XL B

SEASONAL DISTRIBUTION BY WEEKS

% of Total Collections

Larvae

Week of Year	27	28	29	30	31	32	33
Total Collections	296	512	394	515	460	553	585
Aedes atropalpus	0.0	0.5	0.5	0.0	0.4	0.3	0.2
A. aurifer	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. canadensis	0.9	0.0	0.1	0.1	0.1	0.2	0.0
A. cantator	6.4	0.7	2.0	2.0	1.1	0.2	0.6
A. cinereus	3.2	0.5	0.1	0.2	0.2	0.2	0.0
A. dorsalis	0.5	0.0	0.0	0.1	0.07	0.05	0.39
A. excrucians	0.0	0.0	0.0	0.1	0.07	0.0	0.0
A. fitchii	0.4	0.0	0.0	0.0	0.0	0.0	0.1
A. hirsuteron	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. implacabilis	0.0	0.0	0.0	0.0	0.0	0.05	0.04
A. intrudens	0.0	0.0	0.1	0.0	0.0	0.1	0.0
A. punctor	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. sollicitans	0.8	0.0	1.5	1.2	0.6	0.1	0.1
A. stimulans	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. taeniorhynchus	0.0	0.0	0.1	0.0	0.0	0.0	0.0
A. trichurus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. triseriatus	0.4	0.0	0.5	0.1	0.0	0.4	0.5
A. trivittatus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. vexans	6.8	1.4	2.2	0.4	0.9	2.9	1.0
Anopheles crucians	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. maculipennis	0.0	0.0	0.1	0.1	0.3	0.3	0.3
A. punctipennis	4.8	8.4	9.7	10.5	5.7	12.4	14.8
A. quadrimaculatus	1.6	0.5	0.5	0.4	1.8	2.8	5.6
A. walkeri	0.0	0.0	0.0	0.0	0.1	0.4	0.1
Culex apicalis	36.9	40.5	49.3	48.0	43.8	39.1	39.6
C. pipiens	18.9	16.3	18.2	19.4	20.8	22.1	19.2
C. salinarius	2.8	2.3	2.7	1.1	1.5	1.5	0.9
C. territans	11.6	10.7	11.0	11.8	10.0	7.8	8.2
Mansonia perturbans	0.4	0.1	0.0	0.01	0.3	0.1	0.1
Psorophora ciliata	0.0	0.0	0.0	0.0	0.0	0.0	0.17
P. columbiae	0.0	0.0	0.2	0.0	0.0	0.0	0.0
Theobaldia impatiens	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T. inornata	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T. melanura	0.8	0.2	0.6	1.3	1.3	0.7	0.6
T. morsitans	0.4	0.5	0.1	0.0	0.7	0.0	0.0
Uranotaenia sapphirina	0.0	2.7	3.7	3.9	4.4	5.0	4.4
Wyeomyia smithii	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE XL B

SEASONAL DISTRIBUTION BY WEEKS

% of Total Collections

Larvae

34	35	36	37	38	39	40	41	42	43
548	353	381	588	902	839	608	365	126	42
0.3	0.3	0.3	0.3	0.1	0.1	0.1	0.2	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.0	0.2	0.1	0.0	0.3	0.3	0.5	0.7	0.0
0.6	0.4	2.5	1.8	1.0	0.5	0.3	0.2	0.4	0.7
0.1	0.2	1.2	0.3	0.1	0.1	0.1	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.07	0.0	0.0	0.0	0.0	0.0
0.07	0.03	0.03	0.0	0.0	0.0	0.02	0.0	0.07	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.03	0.02	0.0	0.0	0.02	0.0	0.0	0.0	0.0
0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.7	0.1	1.2	0.4	0.2	0.1	0.0	0.1	0.1	0.1
0.0	0.0	0.0	0.02	0.0	0.0	0.0	0.0	0.0	0.0
0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.04	0.0	0.0
0.0	0.28	0.26	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.1	0.1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0
0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.9	1.0	6.0	1.4	0.3	0.1	0.4	0.7	0.3	0.0
0.0	0.0	0.3	0.0	0.0	0.3	0.0	0.27	0.0	0.0
0.3	0.1	0.3	0.1	0.1	0.07	0.06	0.04	0.0	0.0
14.5	16.7	15.0	16.7	17.4	15.3	13.8	14.6	10.7	6.9
5.6	5.4	6.1	6.5	5.7	5.8	4.1	4.4	1.2	1.1
0.1	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.2
38.0	32.7	31.9	29.7	25.7	24.4	24.4	21.1	11.1	6.9
21.4	24.7	24.6	26.1	28.8	34.4	35.5	38.0	41.9	53.4
0.8	1.0	1.5	2.2	1.6	2.8	3.5	3.3	3.9	5.9
9.3	7.5	5.8	7.0	7.6	10.8	10.6	8.9	13.7	8.9
0.1	0.0	0.0	0.02	0.0	0.05	0.06	0.5	0.9	4.8
0.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	0.4	0.3	0.2	0.3	0.7	1.2	0.0	1.7	1.9
0.0	0.0	0.03	0.07	0.0	0.02	0.02	0.0	0.0	0.0
2.7	2.4	2.0	2.0	1.0	0.7	0.4	0.1	0.1	0.0
0.0	0.0	0.26	0.0	0.0	0.0	0.0	0.0	0.0	2.3

TABLE XLI A

SEASONAL DISTRIBUTION BY WEEKS

Number of Collections

ADULTS

Week of Year	27	28	29	30	31	32	33
Total Collections	296	512	394	515	460	553	585
Aedes atropalpus	0	4	1	4	1	3	4
A. aurifer	31	43	22	23	11	10	4
A. canadensis	31	42	39	31	40	32	20
A. cantator	11	14	10	13	20	19	28
A. cinereus	17	26	13	19	16	21	29
A. dorsalis	0	1	0	2	0	0	0
A. excrucians	22	43	34	39	28	31	25
A. fitchii	8	14	9	7	10	14	7
A. hirsuteron	0	2	0	0	0	0	0
A. implacabilis	1	4	1	3	1	0	0
A. intrudens	16	17	9	12	6	4	3
A. punctor	0	1	0	0	0	0	0
A. sollicitans	23	23	11	39	50	46	58
A. stimulans	3	6	6	5	3	3	0
A. taeniorhynchus	0	0	0	0	0	0	0
A. trichurus	0	0	0	0	1	2	0
A. triseriatus	3	6	3	11	9	22	14
A. trivittatus	0	0	0	0	1	0	0
A. vexans	13	11	18	12	15	38	29
Anopheles crucians	0	0	0	0	0	0	0
A. maculipennis	0	0	0	0	0	2	0
A. punctipennis	1	2	4	3	7	13	18
A. quadrimaculatus	0	2	1	7	6	14	27
A. walkeri	0	0	2	2	1	21	5
Culex apicalis	2	10	3	16	19	23	26
C. pipiens	9	21	23	48	51	82	81
C. salinarius	2	3	5	9	10	25	21
C. territans	5	9	14	8	10	21	20
Mansonia perturbans	87	203	174	196	158	147	151
Psorophora ciliata	0	0	0	0	0	0	0
P. columbiae	0	0	0	0	0	0	0
Theobaldia impatiens	0	0	0	0	0	0	1
T. inornata	0	0	0	0	0	1	0
T. melanura	1	3	5	1	0	4	3
T. morsitans	0	0	0	1	1	2	0
Uranotaenia sapphirina	0	1	1	0	0	1	3
Wyeomyia smithii	0	0	0	0	0	0	0

TABLE XLI A

SEASONAL DISTRIBUTION BY WEEKS

Number of Collections

ADULTS

34	35	36	37	38	39	40	41	42	43
548	353	381	588	902	839	608	365	126	42
8	0	7	11	5	0	0	0	0	0
1	0	0	1	0	6	0	0	0	0
4	5	3	3	4	3	6	2	0	0
15	4	21	29	141	118	94	36	4	0
18	10	8	8	22	16	8	4	1	0
0	0	0	0	0	0	0	0	0	0
7	2	4	1	2	0	0	1	0	0
4	0	0	0	1	0	0	0	0	0
0	0	0	0	0	0	8	0	0	0
0	0	0	0	0	0	0	0	0	0
1	1	0	1	2	0	0	2	0	0
0	0	0	0	0	0	0	0	0	0
77	44	74	112	136	111	62	33	0	0
1	0	0	1	1	0	0	0	0	0
0	1	0	6	3	11	0	0	0	0
0	0	0	0	0	0	0	0	0	0
22	15	13	34	4	4	1	2	1	0
0	1	0	0	1	0	0	0	0	0
27	28	40	62	70	67	31	12	3	2
0	0	0	0	0	0	0	0	0	0
2	0	1	0	1	0	0	0	0	0
27	14	12	9	16	20	23	16	8	22
42	12	10	5	8	11	17	11	2	2
9	3	0	0	2	0	4	0	0	1
27	32	34	52	164	161	88	70	14	4
100	84	71	122	162	180	163	84	59	15
21	13	25	35	45	41	56	48	11	5
42	29	39	35	47	47	66	23	13	1
103	50	11	12	4	6	3	7	1	7
0	1	0	0	1	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	1	1	0	0	0	0	0
8	4	2	11	0	1	4	3	1	2
0	1	0	0	0	0	0	0	0	0
1	0	4	1	2	2	0	0	0	0
0	0	0	0	0	0	0	0	0	0

TABLE XLI B

SEASONAL DISTRIBUTION BY WEEKS

% of Total Collections

ADULTS

Week of Year	27	28	29	30	31	32	33
Total Collections	296	512	394	515	460	553	585
Aedes atropalpus	0.0	0.8	0.3	0.8	0.2	0.5	0.7
A. aurifer	10.5	8.4	5.6	4.5	2.4	1.8	0.7
A. canadensis	10.5	8.2	9.9	6.0	8.7	5.8	3.4
A. cantator	3.7	2.7	2.5	2.5	4.4	3.4	4.8
A. cinereus	5.7	5.1	3.3	3.7	3.5	3.8	5.0
A. dorsalis	0.0	0.2	0.0	0.4	0.0	0.0	0.0
A. excrucians	7.4	8.6	8.6	7.6	6.1	5.6	4.3
A. fitchii	2.7	2.6	2.3	1.4	0.7	0.7	0.3
A. hirsuteron	0.0	0.4	0.0	0.0	0.0	0.0	0.0
A. implacabilis	0.34	0.78	0.25	0.58	0.22	0.0	0.0
A. intrudens	5.4	3.3	2.3	2.3	1.3	0.7	0.5
A. punctor	0.0	0.2	0.0	0.0	0.0	0.0	0.0
A. sollicitans	7.8	4.5	3.1	7.6	10.9	8.3	9.9
A. stimulans	1.0	1.2	1.5	1.0	0.7	0.5	0.0
A. taeniorhynchus	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. trichurus	0.0	0.0	0.0	0.0	0.2	0.3	0.0
A. triseriatus	1.0	1.2	0.8	2.1	2.0	4.0	2.4
A. trivittatus	0.0	0.0	0.0	0.0	0.21	0.0	0.0
A. vexans	4.4	2.2	4.6	2.3	3.3	6.9	5.0
Anopheles crucians	0.0	0.0	0.0	0.0	0.0	0.0	0.0
A. maculipennis	0.0	0.0	0.0	0.0	0.0	0.4	0.0
A. punctipennis	0.3	0.4	1.0	0.6	1.5	2.4	3.1
A. quadrimaculatus	0.0	0.4	0.3	1.4	1.3	2.5	4.6
A. walkeri	0.0	0.0	0.5	0.4	0.2	3.8	0.9
Culex apicalis	0.7	1.9	0.8	3.1	4.1	4.2	4.4
C. pipiens	3.0	4.1	5.8	9.5	11.0	14.8	13.7
C. salinarius	0.7	0.6	1.3	1.7	2.2	4.5	3.6
C. territans	1.7	1.8	4.8	1.6	2.2	3.8	3.4
Mansonia perturbans	29.4	39.7	44.2	38.0	34.4	26.6	25.8
Psorophora ciliata	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P. columbiae	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Theobaldia impatiens	0.0	0.0	0.0	0.0	0.0	0.0	0.17
T. inornata	0.0	0.0	0.0	0.0	0.0	0.2	0.0
T. melanura	0.3	0.6	1.3	0.2	0.0	0.8	0.5
T. morsitans	0.0	0.0	0.0	0.2	0.2	0.4	0.0
Uranotaenia sapphirina	0.0	0.2	0.3	0.0	0.0	0.2	0.5
Wyeomyia smithii	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE XLI B

SEASONAL DISTRIBUTION BY WEEKS

% of Total Collections

ADULTS

34	35	36	37	38	39	40	41	42	43
548	353	381	588	902	839	608	365	126	42
1.5	0.0	1.8	1.8	0.4	0.0	0.0	0.0	0.0	0.0
0.2	0.0	0.0	0.2	0.0	0.7	0.0	0.0	0.0	0.0
0.7	1.4	0.8	0.5	0.4	0.4	1.0	0.6	0.0	0.0
2.7	1.1	5.5	4.9	15.6	14.1	15.5	9.9	3.2	0.0
3.3	2.8	2.1	1.4	2.4	1.9	1.3	1.1	0.8	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.3	0.6	1.05	0.2	0.2	0.0	0.0	0.3	0.0	0.0
0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.3	0.0	0.2	0.1	0.0	0.0	0.6	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.1	12.8	9.4	19.1	15.1	13.2	10.2	9.1	0.0	0.0
0.2	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
0.0	0.3	0.0	1.0	0.3	1.3	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	4.5	3.4	5.8	2.4	0.5	0.2	0.5	0.8	0.0
0.0	0.28	0.0	0.0	0.11	0.0	0.0	0.0	0.0	0.0
4.9	7.9	10.5	10.5	7.8	8.0	5.1	3.5	2.4	4.5
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.4	0.0	0.3	0.0	0.1	0.0	0.0	0.0	0.0	0.0
4.9	4.0	5.2	1.5	1.7	2.4	3.8	4.4	6.4	52.4
7.7	3.4	4.2	0.9	.9	1.3	2.8	3.0	1.6	4.7
1.6	0.9	0.0	0.0	0.2	0.0	0.7	0.0	0.0	2.4
4.9	9.1	8.9	8.9	18.2	19.2	14.5	19.2	11.1	9.5
16.3	23.8	13.6	20.6	17.9	21.5	27.6	23.0	46.8	35.7
3.8	3.7	6.7	6.0	5.0	4.9	9.2	13.2	8.7	11.9
7.6	8.2	10.0	6.0	5.2	5.6	10.9	6.3	10.3	2.4
18.9	14.2	2.9	2.0	0.4	0.7	0.5	1.9	0.8	16.7
0.0	0.28	0.0	0.0	0.11	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0
1.5	1.1	0.5	1.9	0.0	0.1	0.7	0.8	0.8	4.8
0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.2	0.0	1.1	0.2	0.2	0.2	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

TABLE XLII A

COLLECTION OF LARVAE

in

RELATION TO POPULATION DENSITY

Species	No Houses	Less Than 5	6-25 Houses	26-100 Houses	Over 100 or Factory	Stable
	Density of Population in Collection Point Area					
Aedes atropalpus	2	2	1	2	0	4
A. aurifer	0	0	0	0	0	0
A. canadensis	6	8	0	0	0	2
A. cantator	20	25	5	1	2	7
A. cinereus	15	18	5	0	0	3
A. dorsalis	0	1	0	0	0	0
A. excrucians	0	3	0	0	0	1
A. fitchii	0	0	0	0	0	0
A. hirsuteron	1	1	0	0	0	0
A. implacabilis	0	0	0	0	0	0
A. intrudens	1	1	0	0	0	0
A. punctor	0	0	0	0	0	0
A. sollicitans	8	9	2	1	1	3
A. stimulans	0	0	0	0	0	0
A. taeniorhynchus	1	2	0	0	0	0
A. trichurus	0	0	0	0	0	0
A. triseriatus	1	4	3	0	0	0
A. trivittatus	0	0	0	0	0	0
A. vexans	44	67	25	3	3	39
Anopheles crucians	0	0	0	0	0	0
A. maculipennis	9	11	5	1	1	8
A. punctipennis	311	526	171	7	49	201
A. quadrimaculatus	142	261	99	6	26	77
A. walkeri	4	4	3	0	1	5
Culex apicalis	525	822	292	17	75	253
C. pipiens	372	630	317	31	96	229
C. salinarius	80	116	56	7	19	48
C. territans	178	275	134	9	37	150
Mansonia perturbans	0	0	0	0	0	0
Psorophora ciliata	0	0	0	0	0	0
P. columbiae	0	0	0	0	0	0
Theobaldia impatiens	0	0	0	0	0	0
T. inornata	0	0	0	0	1	6
T. melanura	29	24	11	1	0	0
T. morsitans	1	1	0	1	12	24
Uranotaenia sapphirina	82	114	40	2	0	0
Wyeomyia smithii	0	0	0	0	0	0
Total	1831	2925	1169	89	323	1060
Percent	24.8	39.6	15.7	1.2	4.4	14.3

TABLE XLII B

COLLECTION OF ADULTS

in

RELATION TO POPULATION DENSITY

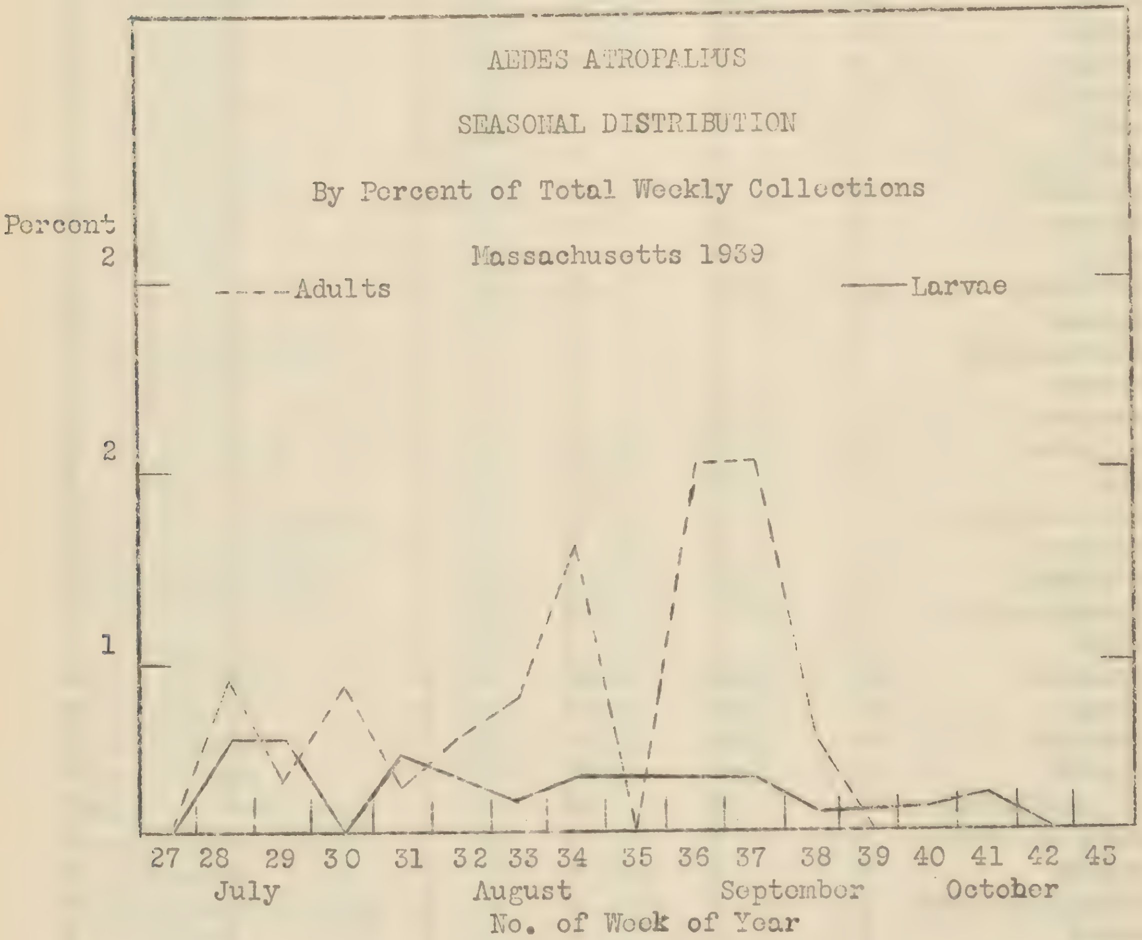
Species	Density of Population in Collection Point Area					
	No Houses	Less Than 5	6-25 Houses	26-100 Houses	Over 100 or Factory	Stable
Aedes atropalpus	0	0	1	0	0	3
A. aurifer	23	19	7	0	2	6
A. canadensis	16	40	8	0	2	3
A. cantator	50	58	21	2	7	23
A. cinereus	34	29	5	1	2	8
A. dorsalis	0	0	0	0	0	0
A. excrucians	11	21	2	0	0	4
A. fitchii	5	5	2	0	0	1
A. hirsuteron	0	0	0	0	0	0
A. implacabilis	1	3	0	0	0	0
A. intrudens	7	11	4	1	1	3
A. punctor	0	0	0	0	0	0
A. sollicitans	51	60	21	2	11	26
A. stimulans	0	5	0	0	0	0
A. taeniorhynchus	2	3	0	0	0	3
A. trichurus	0	0	0	0	0	0
A. triseriatus	10	13	6	1	2	2
A. trivittatus	0	0	0	0	0	0
A. vexans	35	35	14	0	3	5
Anopheles crucians	0	0	0	0	0	0
A. maculipennis	1	0	0	0	0	0
A. punctipennis	13	20	6	1	5	5
A. quadrimaculatus	7	13	4	0	0	7
A. walkeri	1	3	1	0	0	2
Culex apicalis	30	81	52	4	18	22
C. pipiens	48	96	66	8	29	34
C. salinarius	14	30	33	4	12	10
C. territans	17	51	28	1	8	14
Mansonia perturbans	32	69	18	1	7	17
Psorophora ciliata	0	0	0	0	0	0
P. columbiae	0	0	0	0	0	0
Theobaldia impatiens	0	0	0	0	0	0
T. inornata	0	0	0	0	1	3
T. melanura	4	13	3	0	0	1
T. morsitans	0	0	0	0	0	2
Uranotaenia sapphirina	1	4	0	0	0	0
Wyeomyia smithii	0	0	0	0	0	0
Total	413	679	302	26	110	204
Percent	23.8	39.1	17.4	1.5	6.3	12.5

PUBLIC HEALTH IMPORTANCE

Aedes atropalpus

This species has been demonstrated to transmit equine encephalomyelitis in the laboratory. Of the six vectors of this disease known to exist in Massachusetts, it is about fourth in numerical importance, comprising 7.77% of the specimens and 3.62% of the collections of vectors. It was collected from three portions of the state, the Connecticut Valley, Essex County and Cape Cod. The species is probably wider spread as was demonstrated by the collection of adults in the city of Webster located near the junction of the Massachusetts, Rhode Island and Connecticut State lines.

Figure XIV



The mosquito breeds principally in rivers and streams, marshes and swamps, ponds and lakes. It prefers sparsely populated areas. The adults, not avid biters, were collected in houses and stables. The adults are most prevalent during August and September. However, due to the peculiar geographical distribution, and to the small number of A. atropalpus, this species could not have played a role in the 1938 outbreak of equine encephalomyelitis. It is probably not an important natural vector of this disease.

Aedes aurifer

This species has no public health importance as it is not a vector of disease. However, it is one of the species which bites man freely. Its distribution was widespread throughout the state. All collections consisted of adults and no larvae were found.

Matheson has had the same experience in Central New York where adults are abundant and larvae have not been collected. The adults are apt to bite in the open and do not enter buildings as frequently as many of the other species. The adults are most prevalent early in the summer and by August and September are comparatively rare.

Aedes canadensis

This mosquito is not a vector of disease, but is important as a nuisance. The species is widely distributed throughout the state. Larvae were collected in small numbers; mainly in ponds and lakes, running and still water, and marshes and swamps in thinly settled regions. Although not ubiquitous, the larvae are found in many different types of breeding places. The adult bites man in the open, but does enter houses at times. The species is most numerous in the early summer; by July it is decreasing in number and in August and September becomes rare.

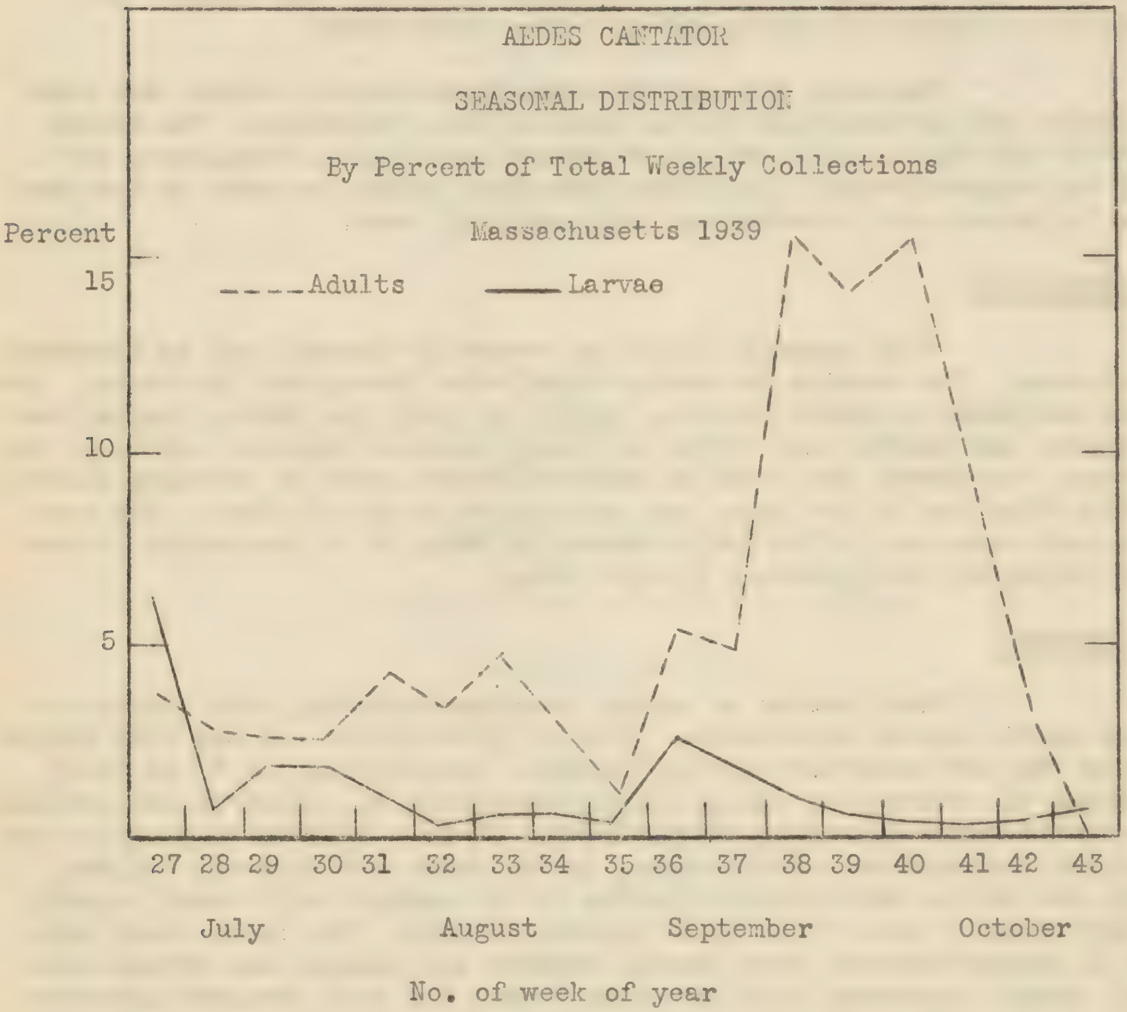
Aedes cantator

As a vector of equine encephalomyelitis, this species is of great public health importance. It is a fierce biter and may have played a role in the 1938 outbreak of this disease. Numerically, it is in first place among the vectors of equine encephalomyelitis in number of collections, and in second place in number of specimens. It is a salt marsh mosquito and limited, in geographical distribution, to the coast and adjacent regions. Usually, the adults were within 10 miles of the nearest salt water; rarely were they found 15 miles from their breeding places. The larvae were collected in largest numbers from coastal marshes and swamps, and streams and rivers. Dumps, cranberry bogs and barrels were the most frequent man-made breeding places. The adults bite man principally in the open but enter houses as well, although in much smaller numbers than other mosquitoes. They have been collected in houses, barns and stables, and in the vicinity of horses and birds which are known to be susceptible to equine encephalomyelitis. The species was most numerous in September and October, when these adults represented 15% of the total adult collections.

This mosquito is one of the three most important natural vectors of equine encephalomyelitis. Its seasonal distribution coincides with that of the disease. Although the geographical distribution is not entirely the same, the mosquito was collected from the area where the outbreak occurred, namely, in Bristol and Plymouth Counties. Collections in Bristol County were, on the whole, poor; this was due in part to the difficulty in obtaining qualified crewmen for this district. It is entirely possible that the spread of the disease may have been due, in part, to its

dissemination by this species which may have been carried by the prevailing west wind into more inland portions.

Figure XV



Aedes cinereus

This Aedes mosquito is not a vector of disease but it is a fierce biter. It is distributed throughout the state, but largest collections were made in the eastern portion. The larvae were found most frequently in marshes and swamps and in running and still water, in less thickly settled areas. Although the adults bite man in the open, the mosquito has been collected in houses, barns and stables. Some adults were collected from a horse, and still others were caught in the vicinity of cattle, horses and mules. The adults were caught in largest numbers early in the season and gradually decreased throughout the summer and autumn. Larvae were collected as late as September

although not to a great extent. This species may be a nuisance early in the spring, but is of no importance as a vector.

Aedes communis

This species was reported by Johnson in 1925 as found in Massachusetts. However, it was not collected during the Survey. Matheson states that the adults appear early in spring and persist until late in the season. He collected the larvae from spring pools, swamps and marshes. This species is probably very unimportant, as it was not picked up in the 49,000 collections made during the Survey.

Aedes dorsalis

This species is one of the rarer Aedes mosquitoes. It is not an important biter and is not known to transmit disease. Scattered collections were made in Franklin County in the west, and along the coastal region in the east. Insufficient collections of larvae were made to ascertain the typical breeding places of this species and the adults were collected even less frequently. One collection of this species was made on man. The species is apparently most abundant early in spring, becomes rare in July and remains so for the rest of the season.

Aedes excrucians

This mosquito is of little importance as a biter. It was found to be state-wide in distribution. The larvae were collected in small numbers; two collections were made in cranberry bogs and one in a dump. The adults bite man and were collected in houses, barns and stables. The adults appeared early in spring and were rare by September. In spring this species may be a nuisance outdoors in certain districts.

Aedes fitchii

Little concern is expressed over this mosquito as it is not a fierce biter and plays no role in the spread of disease. This species wa collected in scattered areas throughout the state. Adults, which were collected on man and in houses and barns, were found only during the early part of the season. Larvae were found in very small numbers. The species is definitely a spring and early summer mosquito.

Aedes hirsuteron

This species is quite rare in Massachusetts. Small collections were made along the coastal regions. Aedes hirsuteron is of no public health importance as it seldom bites man and is small in number. The seasonal prevalence of this species cannot be determined from the collections made during the Survey.

Aedes impiger

This species was not collected by the Survey. Johnson reported it from Massachusetts in 1925. It is rare and little is known about its habits. It is, therefore, an unimportant mosquito.

Aedes implacabilis

This is another rare species of Aedes. The adults were collected during July and August and the larvae were found in small numbers throughout the season. It is an early mosquito with a spring and early summer predominance. The mosquito is unimportant as it is a rare species, is not a fierce biter, and is not known to transmit disease.

Aedes intrudens

Since this species bites man in the open it may be important as a nuisance. It was distributed throughout the state. Larvae were collected in small numbers from cranberry bogs, cesspools, overflows and dumps. The adults were captured on man and in houses. The mosquito was most numerous in the early summer and became rare in August and September.

Aedes punctor

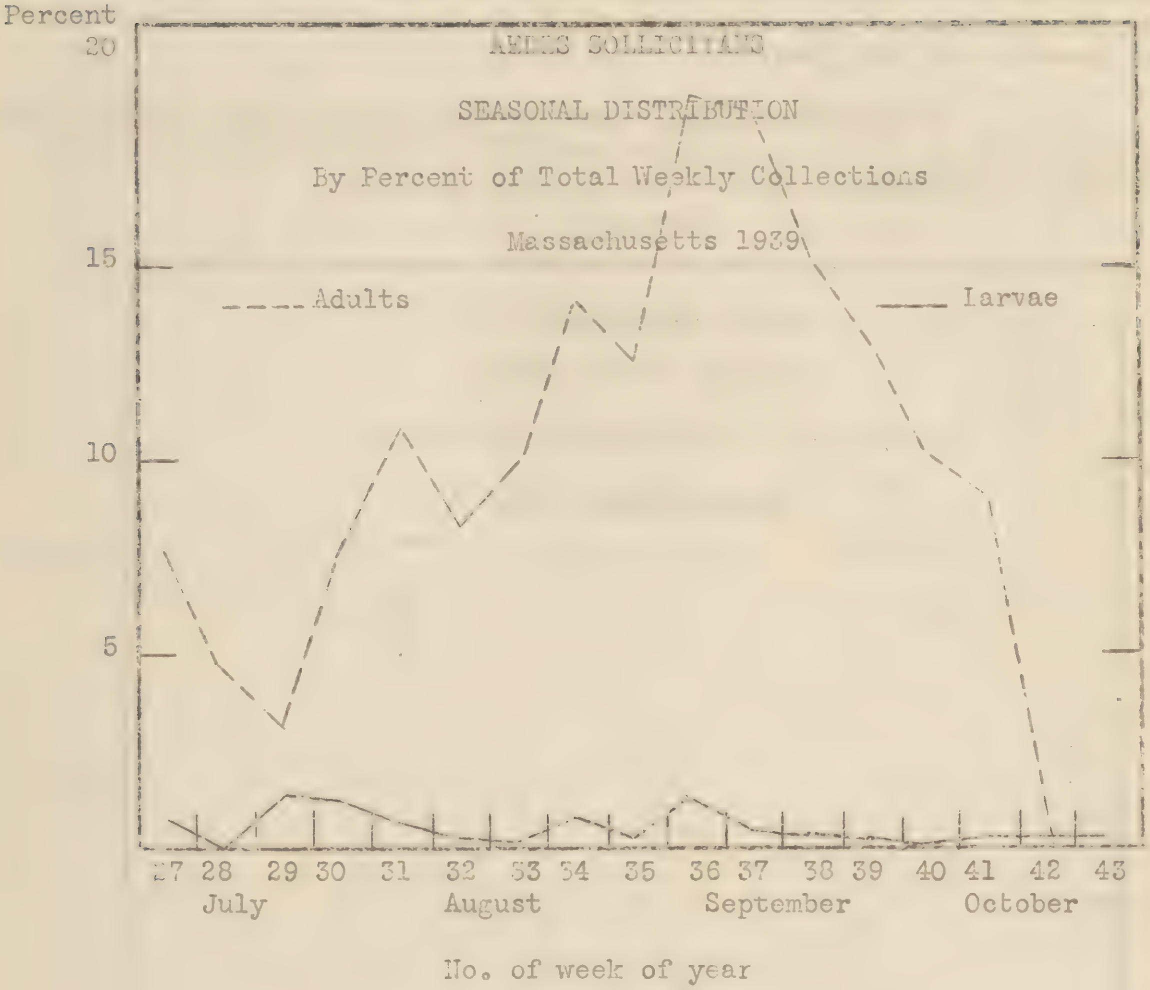
Aedes punctor is a rare species of which only adults were collected. These collections were made in Plymouth and Barnstable Counties. One collection of adults was made in a house. It is an unimportant mosquito.

Aedes sollicitans

This salt marsh mosquito, a fierce biter, is one of the important equine encephalomyelitis vectors. Geographically, it is limited to the vicinity of salt or brakish water. The adults were rarely collected more than fifteen miles from the nearest salt water. Larvae were collected in largest numbers from marshes and swamps. Of all species, Aedes sollicitans was captured most frequently on man. It was collected in houses with the same frequency as Aedes cantator, but less frequently in barns and stables. Collections of adults were made in the vicinity of horses, mules, cattle and birds which are susceptible to equine encephalomyelitis.

This species was ~~not~~ most numerous in August and September. This seasonal prevalence coincides with that of the disease. As in the case of Aedes cantator, the geographical limitation of this mosquito was not the same as that of the disease in 1938. However, mosquitoes were much more prevalent during the outbreak, and wind-borne adults may have been carried inland by the prevailing southwest winds. These species, Aedes cantator and Aedes vexans are probably the most likely natural vectors of equine encephalomyelitis.

Figure XVI



Aedes stimulans

This mosquito is not known to transmit disease; it is not a fierce biter and is numerically unimportant. Larvae were collected in scattered areas throughout the state. Adults were captured on man in two instances, a collection was made in a stable and in a house. This species predominates in the spring and by August is quite rare.

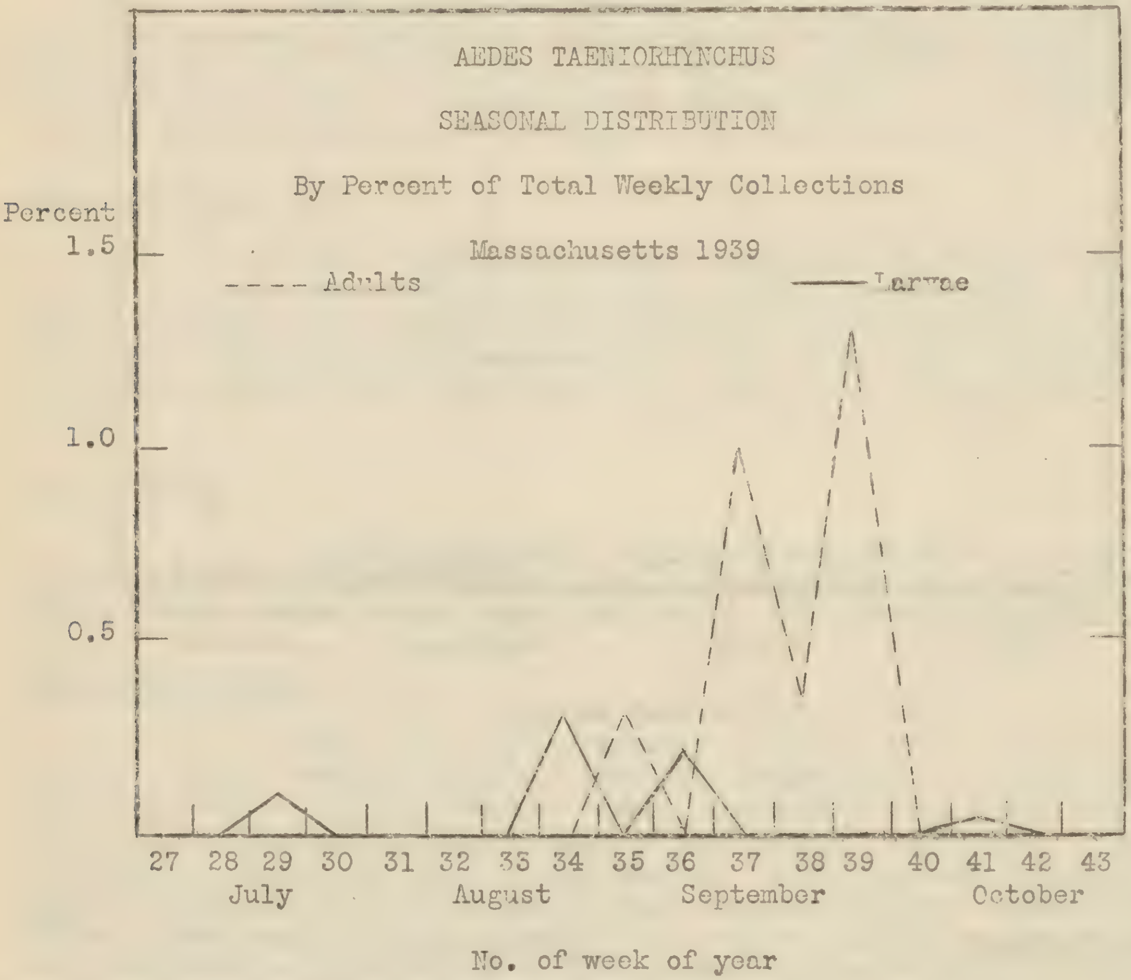
Aedes taeniorhynchus

This southern salt marsh mosquito is a vector of equine encephalomyelitis. It is a fierce biter but occurs in such small numbers and is so limited in geographical distribution that it is not of any great public health importance. Its collection was limited to the island of Martha's Vineyard and to the Buzzard's Bay region of southern Massachusetts. Larvae were found in marshes and swamps. Since most of the adults were

captured on man, this species probably does not frequent houses. The adults were captured in August and September and it is apparent that the species is most numerous at this time.

It is very unlikely that Aedes taeniorhynchus played a role in the 1938 outbreak of equine encephalomyelitis, unless its distribution extended further northward in 1939 than it did in 1938.

Figure XVII



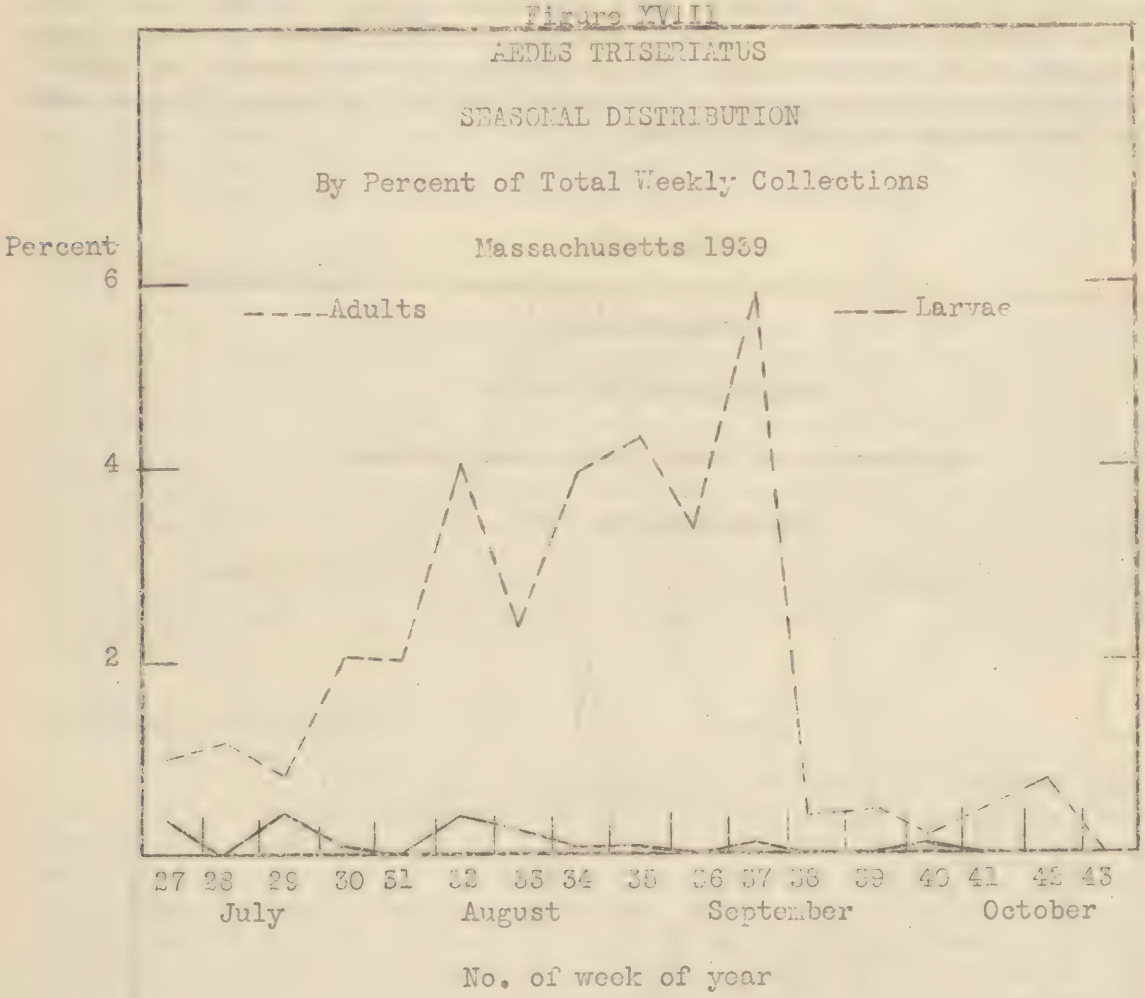
Aedes trichurus

This is a rare species which is unimportant as a nuisance and as a public health menace.. This mosquito was collected so infrequently that no conclusions concerning its life habits can be made. It is probably an early mosquito with a spring predominance.

Aedes triseriatus

Laboratory experiments have demonstrated that this species can transmit equine encephalomyelitis. It was found to be state-wide in distribution but was less numerous than Aedes vexans which is another vector of this disease. The larvae were collected from barrels, wells, dumps and water troughs. Adults were captured in houses more frequently than on man. Collections were made as frequently in thickly settled areas as in rural sections. The species was most numerous in August and the first three weeks of September but decreased rapidly during the last week of September.

Figure XVIII



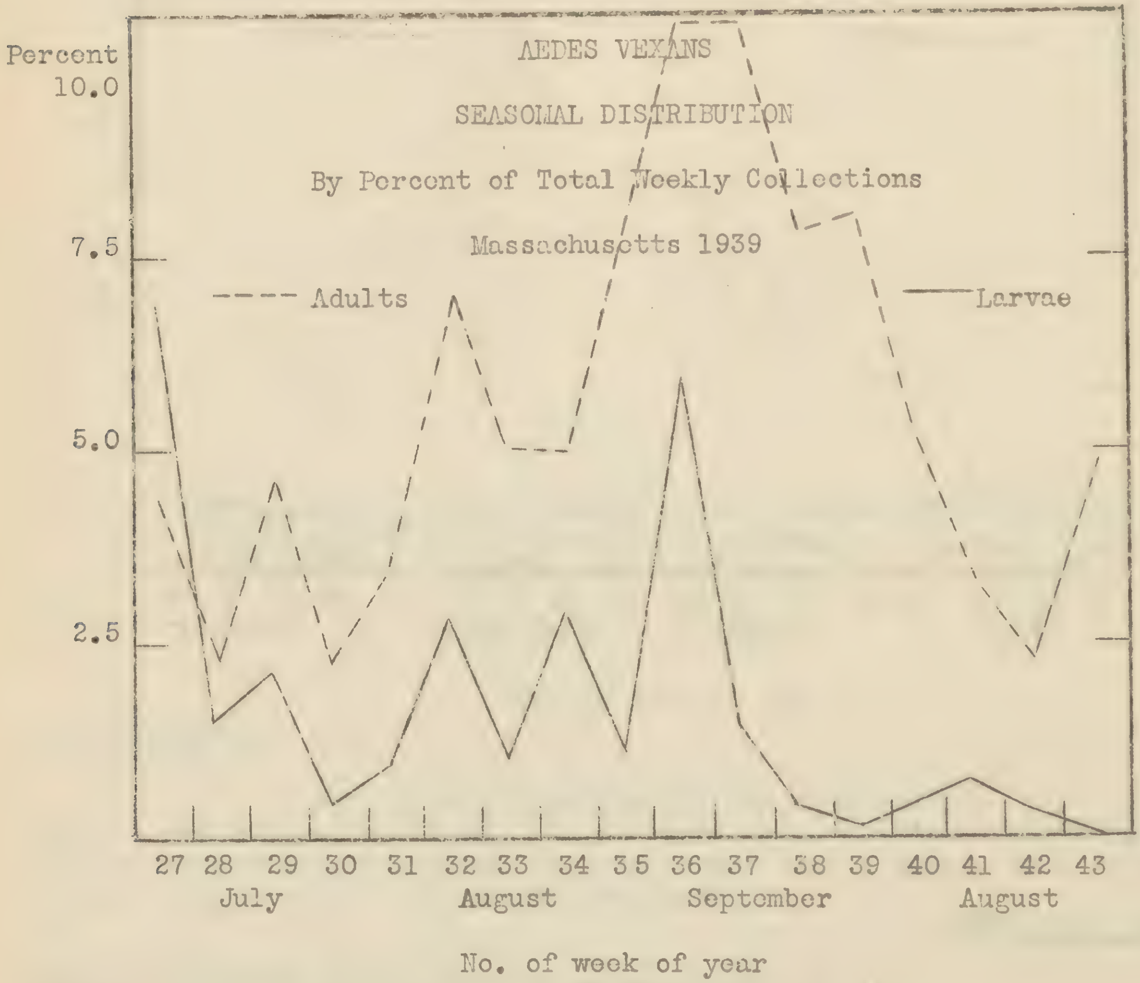
Aedes trivittatus

This is a rare species of very little importance; Aedes trivittatus larvae were collected in two towns and adults in three. Since

Aedes vexans

This species, a demonstrated vector of equine encephalomyelitis, is state-wide in distribution and one of the most numerous of the vectors. The larvae are ubiquitous in their breeding habits; collections were made from marshes, swamps, ponds, lakes, streams, rivers, cranberry bogs, puddles, dumps, barrels, a water trough, a well and a rocky crevice. The adults are fierce biters and were frequently collected on man, in stables, barns and in houses. Although more collections were made in rural areas, urban communities were not without this mosquito. This species was collected more frequently in barns and stables than any other Aedes. It was also captured in the vicinity of horses, mules, cattle, and many kinds of birds. Aedes vexans was most prevalent in August and September. It was present in large numbers in July, and, probably would have been present in larger numbers were it not for the drought in July and June.

Figure XIX



It is conceivable that this species was involved in the 1938 outbreak of equine encephalomyelitis. It is the only numerous vector that was found in all areas where the disease occurred. In fact, its distribution was far more extensive than the area involved in the outbreak. It was the most numerous of the vectors if the number of specimens is considered, and second most numerous on the basis of collections. It is not unlikely that Aedes vexans may prove to be the most important natural vector of equine encephalomyelitis.

Anopheles crucians

This species was collected for the first time in Massachusetts. The larvae alone were found in four towns. No adults were collected. In some parts of the south, A. crucians may act as a vector of malaria. However, it is so rare a species in Massachusetts that it is unimportant as a vector and as a nuisance. No conclusions on the breeding habits can be drawn from the few collections obtained.

Anopheles maculipennis

This Anopheline is the second most important vector of malaria in Massachusetts. Since malaria is not a problem at the present time, vectors of malaria are not an immediate concern. This species is state-wide in distribution but is numerically unimportant. Of the five Anopheles, it is third in numerical importance. Larvae were collected from rivers and streams, marshes and swamps, ponds and lakes, excavations, a puddle and a water trough. The species breeds principally in sparsely settled areas. Adult collections were few; seven specimens were captured in houses. The seasonal predominance of this species is apparently in July and August; this observation, however, is based on relatively few collections.

Anopheles punctipennis

Although A. punctipennis may transmit malaria experimentally, it is not an important natural vector. It is, therefore, unimportant except as a nuisance. It is by far the most numerous Anopheline, and was collected in most of the cities and towns in Massachusetts. The larvae are ubiquitous in their breeding habits as can be seen from the list of breeding places. In this respect, it resembles C. apicalis and C. pipiens. Frequently the adults were captured in houses. Some were caught on man and a few in stables. Although more numerous in rural sections, urban communities were not free of them. The species continues at about the same level throughout the mosquito season, with a tendency to increase, until the onset of cold weather. The sudden rise in adults during the second half of October, is probably due, not to an actual increase in the species, but to the small number of total collections of adults.

Anopheles quadrimaculatus

This mosquito is the important malarial vector in the United States. It is an avid biter and was collected from all sections of the

state. The larvae breed ubiquitously. Most productive breeding places were rivers and streams, ponds and lakes and marshes and swamps. The adults were collected in densely as well as sparsely populated areas. Many adults were captured in buildings, some in barns and a few on man. This species was most predominant during August and September. Few were found in July, due no doubt to the lack of rain.

As the chief vector of malaria, A. quadrimaculatus is a concern of the public health official. However, at the present time, malaria is rare in Massachusetts and there is no apprehension over this vector's wide geographical distribution.

Anopheles walkeri

Due to its small numbers, A. walkeri is unimportant as a vector of malaria. It was collected throughout the state. The larvae were found from July through October. Most of these were collected at other than regular collection points. The adults were captured in houses and in the vicinity of stables, horses and mules. The seasonal distribution of this species cannot be determined from the collections, but most of the adults were caught in August. The apparent increase of adults late in October may be due to the small number of collections made at that time.

Culex apicalis

Because this species is known not to bite man it has no public health importance. C. apicalis and C. pipiens are the two most numerous mosquitoes in the state. The former breeds anywhere and everywhere and was collected from all types of breeding places, often in association with other species. It is found in rural and urban sections. Adults enter houses in large numbers, and a few adults were caught in stables and barns. Six specimens were captured on man.

The larvae were most numerous in July and gradually decreased as the season advanced. The adults, however, increased as the season advanced. They apparently survive until the advent of cold weather.

Culex pipiens

As the most numerous species in the state and as a vicious biter, C. pipiens is a nuisance in many parts of the Commonwealth. It was collected from almost every town and city. Larvae are ubiquitous and breed in all types of breeding places, appearing in successive broods throughout the season. The adults were so numerous that they were captured everywhere. C. pipiens was collected in houses, in barns and in stables more often than other species. It will bite man in the open. The species steadily increased in number throughout the season but was most prevalent in September and October.

Experimental transmission of equine encephalomyelitis has been unsuccessful with this species; hence, C. pipiens is important only as a nuisance.

Culex salinarius

This mosquito is important only as a nuisance. It is far less numerous than C. pipiens. Its geographical distribution is state-wide. The larvae were collected from all types of breeding places in both rural and urban sections. Adults were frequently captured in houses, some were caught in barns and stables, and a few on man in the open. Like C. pipiens this species continued to increase in numbers as the season advanced. Collections were most frequent in late September and October.

Culex territans

Except as a nuisance this mosquito is of no importance. It was collected throughout the state. The larvae are almost as ubiquitous as those of C. pipiens and breed in many different types of water. Collections were made in both rural and urban communities. Adults were frequently captured in houses, a few were caught on man, and occasional collections were made in barns and stables. There was no definite seasonal predominance. The species was numerous at all times although adults increased with the advance of the season.

Mansonia perturbans

This mosquito is a fierce biter and was the cause of many complaints. It is state-wide in distribution and is important because of its large numbers. The larvae, which attach themselves to water plants, were collected in small numbers. The adults were caught in houses and in barns and stables almost as frequently as C. pipiens, and during the spring and early summer were a chief nuisance indoors. They were captured more often on man than any other species except A. sollicitans. This species cannot transmit equine encephalomyelitis in the laboratory and, hence, is of importance only as a nuisance.

There was a definite seasonal predominance; the adults were most numerous in July, and gradually decreased in number thereafter.

Orthopodomyia signifera

Larvae of this species were collected in the town of Sudbury from a wooden barrel containing rain water. Several collections were made during the 32nd week (August 6-12).

This is the first time this genus was recorded from Massachusetts. It is of no importance, as it is not known to bite man and is very rare.

Psorophora ciliata

This species is one of the largest mosquitoes of Massachusetts and is a fierce biter. It is rare and was collected only in the Connecticut River Valley and on Martha's Vineyard, a large island south of Cape Cod. Because of its small numbers it is of no importance as a nuisance. It is not

known to transmit disease. The adults were captured in June and August and the larvae in July.

Psorophora columbiae

Only larvae were collected of this species. It is said to be a fierce biter but is too rare to be of any public health importance. The larvae were collected in Hampshire County in July and August.

Psorophora posticata

This species was reported from Massachusetts by Johnson in 1925. It is rare and was not collected during the Survey. It is said to be a severe biter.

Theobaldia impatiens

The genus Theobaldia is rare in Massachusetts. It was collected in this state for the first time during the Survey. Two collections of adults were made in northern Massachusetts in August and the other in September. No larvae were found. This species is said not to be a persistent biter, and is of no public health importance.

Theobaldia inornata

Three collections of adults were made of this rare species. The specimens were captured in August and September. No larvae were found. It is of no public health importance.

Theobaldia melanura

Of the genus Theobaldia, this species is most numerous. It was collected throughout the state. Larvae were found in largest numbers in marshes and swamps, ponds and lakes, rivers and streams and root holes in sparsely settled areas. Both adults and larvae were found throughout the season. Adults were captured on man and also in buildings. The apparent increase in adults late in October consisted of only two collections, which, however, represented 4.8% of the total. This number is too small to be significant. This species is not a vicious biter and has no public health importance.

Theobaldia morsitans

This mosquito is rare in Massachusetts and is unimportant as a nuisance. It was collected in small numbers throughout the state. Larvae were collected most frequently in cranberry bogs. The adults were collected only once in a house. Collections were too few to furnish information as to the habits and seasonal prevalence. This species is not known to transmit disease.

Uranotaenia sapphirina

Being the only species of this genus in Massachusetts, this

mosquito is unimportant as a nuisance and is not known to transmit disease. It is state-wide in distribution. Larvae were collected most frequently in marshes, swamps, ponds, lakes, rivers and streams in rural areas. The adults were captured less often than the larvae and were not found to bite man or to enter houses. The larvae were most numerous in August, whereas the adults were captured too seldom to give an indication of their seasonal prevalence.

Wyeomyia smithii

A very rare species, W. smithii is of no importance except to the entomologist. The larvae were collected at the tip of Cape Cod and the adults in the Berkshires. This species breeds in pitcher plants and is difficult to collect. It, no doubt, breeds in many marshes and swamps where pitcher plants abound.

Chaoborus Species

The sub-family Chaoborinae consists of several genera of mosquitoes whose proboscis is not adapted for bloodsucking. The larvae of these mosquitoes are predatory and are of importance only in that they may destroy the larvae of the Culicinae, or biting mosquitoes. However, this method of natural control is not very effective and all the Chaoborinae are of little importance except to entomologists.

The species of the various genera were not routinely identified. Chaoborus is a genus which is state-wide in distribution. Adults and larvae were collected throughout the duration of the Survey.

Corethrella

Corethrella is another genus of the sub-family of Chaoborinae, the non-biting mosquitoes. It is, therefore, of no importance except as a predator on other larvae.

Mosquitoes in this genus were not routinely identified by species. One species C. brakeleyi is reported here for the first time in Massachusetts. Collections in eastern Massachusetts were limited to larvae during July and September.

Dixa Species

This genus of non-biting mosquitoes is the most numerous of the Chaoborinae whose larvae are predatory on other mosquito larvae. It is state-wide in distribution. Larvae were collected from rivers and streams and from still water. Adults were collected only twice in southern Massachusetts. Collections were most numerous in August and September.

Because of the small numbers of all the Chaoborinae, their predatory habits have little effect in the natural control of the Culicinae.

Eucorethra underwoodi

As a non-biting mosquito this species is important only as

a predator on the larvae of other species. It is rare and was collected in two places; Savoy in the Berkshires and Yarmouth on Cape Cod. The larvae were collected in streams. No adults were found.

Mochlonyx Species

This genus belongs to the sub-family Chaoborinae which are non-biting mosquitoes. Except as a predator in the larvae of biting mosquitoes, it has no importance. This genus was collected in Barnstable, Dukes and Plymouth Counties, all in southeastern Massachusetts. Only larvae were collected in both running and still water.

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CHAPTER XVI

CONCLUSIONS ON THE MOSQUITO TRANSMISSION OF EQUINE ENCEPHALOMYELITIS

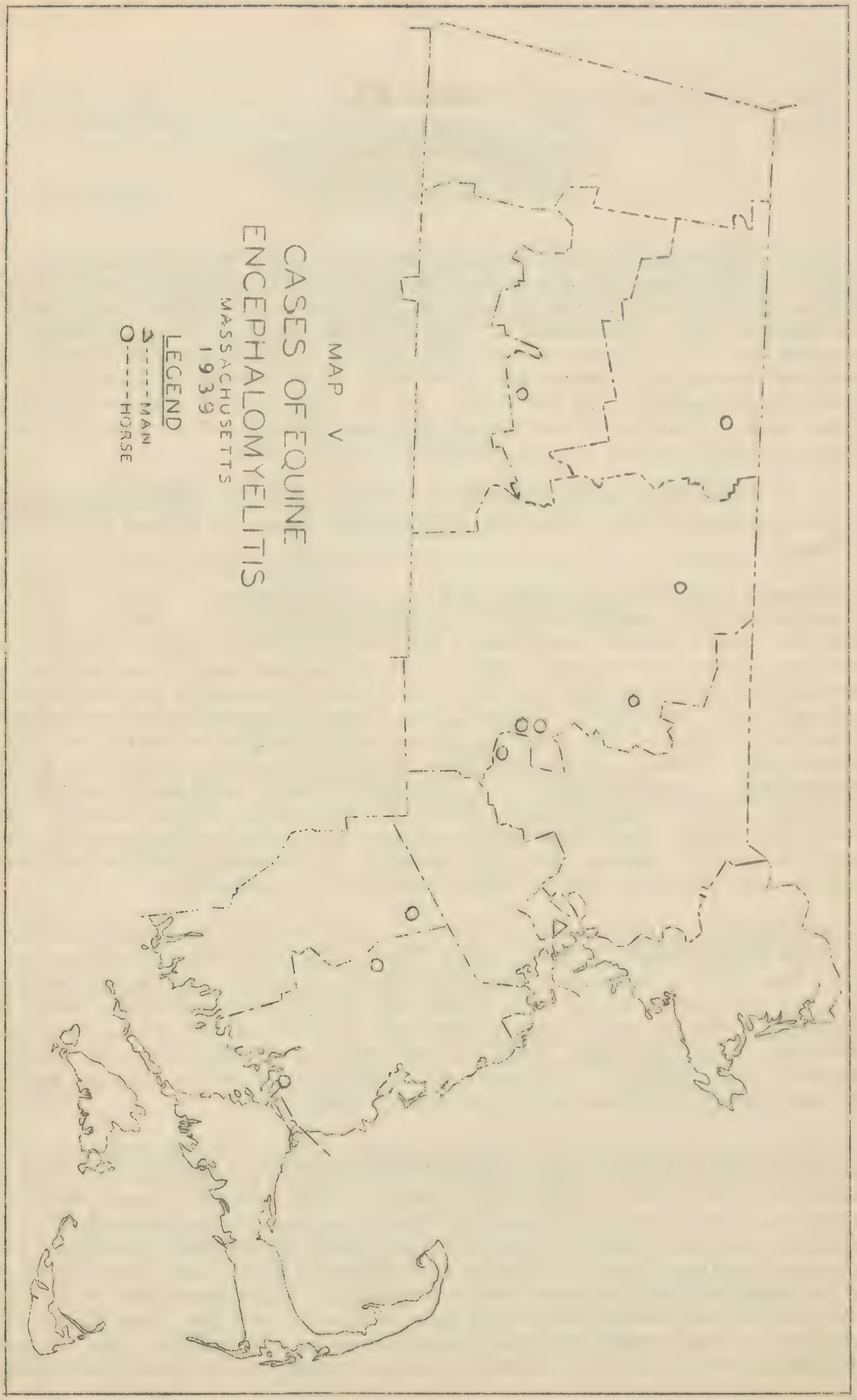
Epidemiological investigations have supported the laboratory observations that mosquitoes are capable of transmitting equine encephalomyelitis. Field observations reveal the confirmatory evidence that mosquitoes are abundant during outbreaks of this disease. During the Massachusetts epidemic of 1938, mosquitoes were observed to be unusually numerous in the same area where the disease was prevalent. It was observed that the disease moved, principally to the northeast, in the direction of the prevailing winds; and, it has been postulated, that mosquitoes were carried by these winds, thereby causing a rapid spread of the disease.

Data, collected by the Survey, has furnished additional epidemiological support to the mosquito transmission theory of equine encephalomyelitis.

1. *Seasonal Prevalence of Vector and Disease Correspond* For the effective transmission of a mosquito-borne disease, there must be a certain minimal numerical ratio between the vector, host and would-be host. When the vectors are unusually prevalent, this ratio rises, and conditions for increased transmission are present. In 1938, the outbreak reached a peak in late August and early September. In 1939, the seasonal prevalence of mosquitoes was determined. Whereas the genus *Aedes* was more abundant in spring and early summer, the vectors, *Aedes atropalpus*, *A. cantator*, *A. sollicitans*, *A. taeniorhynchus*, *A. triseriatus* and *A. vexans* were most numerous in August and September. The seasonal prevalence of the vector and of the disease correspond. Therefore, conditions most conducive to the transmission of the virus exist in the late summer and early autumn. The unusual abundance of mosquitoes in 1938 provided optimal conditions for the outbreak.

2. *Geographical Distribution is the Same* The vectors of equine encephalomyelitis were present in these areas where, formerly, the disease was present. Four of the vectors, *A. sollicitans*, *A. cantator*, *A. vexans* and *A. triseriatus* were found in the area where most of the cases existed. Only two vectors, *A. vexans* and *A. triseriatus* were present in all places where cases occurred. *A. triseriatus*, however, was found to be only 1/5th to 1/15th as numerous as *A. vexans*. Therefore, statistically, it seems that *A. vexans* is the most important vector of equine encephalomyelitis.

3. *Aedes vexans is the Most Probable Natural Vector* Further confirmatory evidence in the support of *A. vexans* as the vector is found in the distribution of equine encephalomyelitis cases in 1939. Twelve cases, which are spotted on Map V , were diagnosed by the Massachusetts Department of Agriculture. Although most of these were diagnosed on clinical findings, the virus was isolated from the brains of two horses which had lived and died in the towns of New Braintree and Westborough. These towns are so far inland that no salt marsh mosquitoes were collected and the probability of a mosquito of this group infecting these horses is negligible. The nearest breeding place of the salt marsh vector was twenty miles from Westborough


MAP V
CASES OF EQUINE
ENCEPHALOMYELITIS
MASSACHUSETTS
1939
LEGEND
△-----MAN
O-----HORSE

and over fifty miles from New Braintree. Fifteen miles away from their breeding places is the greatest distance at which the adult salt marsh mosquitoes, A. sollicitans and A. cantator, were collected. When wind-borne, both species have been recorded to fly farther. Here, however, the prevailing winds in the summer and early autumn blow from the west and southwest. Salt marsh mosquitoes would have to fly against the wind for twenty to fifty miles to reach those two towns. Furthermore, long flights of salt marsh mosquitoes are a rare phenomenon, so, statistically, the chances of a few adults surviving such long flights are almost negligible. All these facts point to a mosquito other than the salt marsh Aedes as the carrier. Only two vectors were found in this area, A. triseriatus and A. vexans. Since A. vexans is five to fifteen times as numerous as the former, statistically, A. vexans is the most probable vector responsible for the infection of these horses.

4. Age Distribution of Cases is Explained by the Bionomics of Vectors The termination of the bionomics of the vectors of equine encephalomyelitis offers explanations of several phenomena observed in the 1938 outbreak. Twenty-six percent of the cases in man were infants under one year of age, and twenty percent were children under ten. Although detailed information about individual cases has not been obtained, the high attack rate among the younger age groups may be explained by the following observations. During the summer, infants are often left to sleep outdoors, sometimes without protective netting, and are unable to defend themselves against mosquitoes. Moreover, children under ten who play outdoors the greater part of the day are less efficient than older groups in protecting themselves as they do not react to a mosquito until it has bitten them. Thus, indications are that infants and children who sleep or play outdoors are more apt to be bitten than older individuals who, taught by experience, react to the buzzing or alighting of a mosquito.

Of all mosquitoes captured on man outdoors, sixty percent were vectors, while only six percent of those caught indoors were carriers. Therefore, the chances are three out of five that a mosquito which has bitten an individual in the open is a vector, while indoors the chances are three out of fifty that the biting mosquito is a carrier. These findings explain why infants and children comprise such a high proportion of the cases.

5. Vectors Bite Horses Outdoors It was observed that horses which spent the greater part of their existence outdoors, formed the larger portion of the cases. Data collected during the Survey indicates that the vectors are more likely to bite in the open rather than indoors. Hence, horses which are outdoors are more apt to be infected.

6. Summary of Conclusion The summation of these facts establishes the theory of the mosquito transmission of equine encephalomyelitis on an epidemiological basis. Laboratory experiments have demonstrated mosquito transmission of the disease. The combined evidence of the laboratory and the field is tantamount to proof of this theory. Although some individuals may not consider necessary the finding of a mosquito which is naturally infected with the virus of equine encephalomyelitis, this discovery is, nevertheless, a logical sequel to the experimental work in the proof of this theory.

CHAPTER XVII

SUMMARY

MOSQUITO-BORNE DISEASES IN MASSACHUSETTS

1. Various investigators have observed that mosquitoes were abundant during outbreaks of equine encephalomyelitis and suggested that the disease may be mosquito-borne. Experiments conducted in several laboratories have demonstrated that certain Aedes mosquitoes can transmit the disease. The theory of mosquito transmission was, thereby, established upon experimental evidence but needed further epidemiological confirmation.

2. During August and September of 1938, an outbreak of the eastern variety of equine encephalomyelitis in southeastern Massachusetts reached a peak. About three hundred horses succumbed to the disease. In man there were thirty-four cases, 26% of which were infants under one year of age and 70% were children under ten. The disease ran a rapid fulminating course with a case fatality of 74%. A follow-up of the eight survivors one year later, revealed the presence of sequelae in 83%.

3. The Mosquito Survey was organized by the Massachusetts Department of Public Health in cooperation with the Work Projects Administration to determine "the prevalence, and seasonal and geographical distribution of mosquitoes throughout the Commonwealth", and to ascertain the relationship of these insects to equine encephalomyelitis and other mosquito-borne diseases.

4. At the present time, malaria is the only other mosquito-borne disease in Massachusetts. Three epidemic waves have spread over the state in the past 150 years. Twenty-five years ago, malaria was endemic in three areas in the state. During the past ten years, however, there were only eleven cases which were naturally acquired within the state. Although malaria is not prevalent now, it may be reintroduced and become a serious problem.

5. Several other mosquito-borne diseases may be introduced into Massachusetts, namely, yellow-fever, which was epidemic here in the 18th century, dengue and filariasis, both of which are endemic in the south. Two diseases suspected of mosquito transmission which may become local problems are St. Louis encephalitis, which has not been reported in this state but which is widespread throughout the United States, and lymphocytic choriomeningitis, which is being diagnosed in Boston at this time. Formerly, poliomyelitis was suspected of being spread by mosquitoes, but evidence indicates that it is not transmitted in this manner.

6. The most effective control of mosquito-borne disease is the control of vectors. Some measure of control may be obtained by the immunization of susceptibles, as in yellow fever. With the exception of the vaccine for the protection of horses against equine encephalomyelitis, this method is not applicable to other mosquito-borne diseases. Control of these diseases, therefore, depends upon effective control of the vectors. However, before a mosquito control program is launched, data on the bionomics and the seasonal and geographical distribution of the vectors must be obtained by a survey.

THE ADMINISTRATION OF THE MOSQUITO SURVEY

7. In 1939 from June to November inclusive, the Survey was made throughout the state. One hundred seven Work Projects Administration collectors and volunteer collectors solicited through the cooperating local boards of health, submitted 278,887 specimens in 49,231 collections. An office personnel of thirty-two Work Projects Administration employees administered the Survey and prepared the report. The field and office personnel was under the direction of a project supervisor. Nine entomologists employed by the state, made special collections, identified the specimens and assisted the technical director of the Survey in supervising, directing and administering the Survey.

8. Work Projects Administration supervisors, foremen and assistant foremen, and the heads of the various office departments were given a one week training in a course consisting of lectures, laboratory exercises and field trips. These individuals, in turn, trained members of their crews in the recognition and collection of mosquitoes. A bulletin entitled "Training Course for Field Personnel" containing the lectures given during this week was published by the Survey.

9. The field personnel consisted of five supervisors who directed twenty crews distributed throughout the state and averaging five men. Each crew was provided with two automobiles; one was used by the foreman to visit boards of health and groups of volunteer collectors, while the other was used to transport the crew. The plan of the Survey called for weekly collections in every town in the state. Therefore, each crew was given a schedule which provided for collections in each town to be made by one man, one day each week. The crew members were transported to the towns where they walked between the collection points. At the end of the day they were met by the automobile at a designated place and brought back to the headquarters.

10. In order to obtain data on the ecology and bionomics of mosquitoes, collections were made weekly at regular collection points. The collection point was defined as an area with a radius of one hundred yards. These points were spotted on maps and surveyed on special forms. Labels accompanied each collection, and contained information on conditions at the time of the sampling.

11. Special collections were made with light and animal-baited traps on farms where cases of equine encephalomyelitis were reported. Unfortunately, due to adverse conditions, small numbers of mosquitoes were collected, and no true sampling of the mosquito fauna was made in the environment of cases.

12. Permanent collections of larvae, adults and hypopygial mounts were prepared. A new key for the identification of mosquitoes was published in Psyche 46: 113-136, December 1939.

13. The data gathered by the Survey was summarized on special forms, and then analyzed on the ninety-hole punch card. Two sets of cards were used. One set consisted of data assembled from regular collections, and was used to obtain facts on the bionomics and ecology of mosquitoes. The second set contained all the data collected in the Survey, and was used to determine the

prevalence, and seasonal and geographic distribution of the different species.

14. Numerous bulletins were released during the Survey, including the training course for collectors, and a series of pamphlets entitled "Massachusetts Mosquitoes". The objectives of these publications were to:

1. Promote the enrollment of volunteer collectors.
2. Inform all collectors how to distinguish mosquitoes from related insects, and how to collect larvae and adults.
3. Impart information about mosquitoes to the public.
4. Report the results of the Survey.

15. Material for a series of public exhibits on mosquitoes and their relation to disease were prepared by the Survey. These exhibits are being displayed at the Food and Drug Show, The New England Museum of Natural History, the annual convention of the Massachusetts Medical Society and the Eastern States Exposition.

MASSACHUSETTS MOSQUITOES

16. Collections of mosquitoes were made without selection, so as to have a true sample of the mosquito fauna. There was no significant association between the sizes of the communities, both in area and population, and the number of collections. The average number of collections per town was 106, and the average per square mile was nine. Over 85% of the collections were made by the Survey personnel.

17. The effect of meteorological conditions upon the prevalence of mosquitoes may be summarized as follows:

1. Increased rain results in increased prevalence about two weeks later.
2. The accumulation of excess degree days of temperature results in increased prevalence.
3. The prevailing winds from the south and southwest carry adults from salt water breeding places inland to the east and northeast.
4. The peak of the 1938 outbreak of equine encephalomyelitis occurred about four weeks after rain. This interval of time is sufficient for mosquitoes to develop, become infected, undergo an extrinsic incubation period, and infect horses, which become ill in three or four days.

18. The collections of larvae from different types of breeding places was unselected, and consisted of true sampling. There was no statistical significant difference in the number of species breeding in the various types of places. Collections of larvae were most numerous from rivers, streams, ponds, lakes, marshes and swamps. The occurrence of the various species in twenty types of breeding places is described in detail.

19. The vast majority of adult mosquitoes were collected by placing the killing tube over the resting insect rather than by sweeping with the net. Of the 1,977 mosquitoes caught on man outdoors, Aedes sollicitans was the most numerous. The vectors of equine encephalomyelitis comprised 59.9% of these specimens. Of a total of 3,130 adults captured in houses, Culex pipiens was the most numerous, and the vectors of equine encephalomyelitis comprised only

6% of the total. Only 211 specimens were collected in barns and stables; here, Culex pipiens was the most numerous, and the vectors of equine encephalomyelitis comprised about 16%.

20. Of the six vectors of equine encephalomyelitis, Aedes cantator A. sollicitans and A. vexans each constitute about 30%, and A. atropalpus, A. triseriatus and A. taeniorhynchus together comprise 10%. The prevalence of vectors in the counties varied significantly. Vectors constituted over 75% of the adult mosquitoes captured in Dukes County, 21 to 30% in Barnstable, Essex and Norfolk Counties, 11 to 20% in Bristol, Franklin, Hampden, Plymouth and Suffolk, and less than 10% in Berkshire, Hampshire, Middlesex and Worcester Counties. Vectors comprised 25.6% of the total adult collections in the state. In the coastal areas, A. sollicitans was usually the most numerous vector. In all other parts of the state A. vexans was the prevailing vector, and from five to fifteen times as numerous as other vectors.

21. There are five Anopheles mosquitoes in Massachusetts, all of which may act as vectors of malaria. A. quadrimaculatus, however, is the only important vector, and is state-wide in distribution. A punctipennis is the most numerous, and, because of its large numbers, may play a role in the transmission of malaria. A. maculipennis is much less numerous, A. walkeri and A. crucians are both rare. Whereas only 0.5% of the adults captured on man outdoors were Anopheles, 16% of those caught in houses were malaria vectors. Anopheles enter houses much more frequently than Aedes.

22. In Massachusetts, there are nine genera of Culicinae and five of Chaoborinae. The former are provided with a proboscis for bloodsucking and contain forty-one species; three, Anophelew crucians, Psorophora columbiae and Theobaldia impatiens were collected by the Survey for the first time in Massachusetts. The Chaoborinae are important only because their larvae are predatory on those of other species. There are fifteen species of these non-biting mosquitoes in this state. All of them are rare and, hence, unimportant as a method of natural control of mosquitoes. Two species, Eucorethra underwoodi and Corethrella brakeleyi were found by the Survey for the first time in Massachusetts. The prevalence, seasonal and geographical distribution, bionomics of larvae and adults, and the public health importance of each species is discussed in detail. The following table lists the species of Massachusetts mosquitoes.

23. The epidimiological and entomological data collected by this Survey supports the laboratory evidence that equine encephalomyelitis is transmitted by mosquitoes. The occurrence of the disease, and the vectors in the same area, has been established. The seasonal prevalence of the disease and the vectors has been found to be the same. The bionomics of the vectors have been studied, and it has been ascertained that vectors of equine encephalomyelitis prefer to bite man and animals outdoors rather than in buildings. Some of the observations made during the 1938 outbreak are explained by these findings. Small children and infants, who comprised 70% of the cases, are that portion of the population which, during summer, spends a large portion of its time outdoors and, at the same time, is least able to protect itself from mosquitoes. It is to be expected that this group would be bitten more often by the vectors which were collected on man outdoors ten times as often as they were caught in

houses.

The mosquito transmission of equine encephalomyelitis is, thus, firmly established on a laboratory, epidemiological and entomological basis. The proof of this theory may not be obtained for many years, but the finding of a mosquito naturally infected with the virus of equine encephalomyelitis, although considered unessential by some, is the logical and conclusive sequel in this chain of evidence.

TABLE XLIII

SUMMARY
of
MOSQUITOES OF MASSACHUSETTS

	ADULTS		LARVAE	
	No. of Specimens	No. of Collections	No. of Specimens	No. of Collections
SUBFAMILY CULICINAE				
Aedes atropalpus	60	41	995	77
A.aurifer	542	186	0	0
A.canadensis	770	301	495	122
A.cantator	1326	599	2704	399
A.cinereus	471	256	482	121
A.communis*	0	0	0	0
A.dorsalis	4	4	79	14
A.excrucians	485	268	41	15
A.fitchii	196	95	21	5
A.hirsuteron	7	4	4	4
A.implacabilis	29	16	10	3
A.impiger*	0	0	0	0
A.intrudens	295	131	48	8
A.punctor	6	5	0	0
A.sollicitans	2548	802	1054	145
A.stimulans	59	38	8	2
A.taeniorhynchus	20	18	112	17
A.trichurus	20	8	2	2
A.triseriatus	228	159	92	33
A.trivittatus	6	3	1	1
A.vexans	1052	454	5358	519
Total Aedes	8124	3338	9504	1487
Anopheles crucians**	0	0	20	7
A.maculipennis	30	5	113	58
A.punctipennis	300	192	20396	5757
A.quadrimaculatus	790	182	6810	1729
A.walkeri	57	28	84	31
Total Anopheles	1177	407	27423	7582
Culex apicalis	1746	688	78944	13051
C.pipiens	3360	1313	103138	11640
C.salinarius	832	339	2215	922
C.territans	943	398	23353	3527
Total Culex	7401	2738	207650	29140
Mansonia perturbans	6665	1320	662	69
Orthopodomyia signifera**	0	0	3	1
Psorophora ciliata	4	4	2	2
P.columbiae**	0	0	3	3
P.posticata*	0	0	0	0
Total Psorophora	4	4	5	5

TABLE XLIII
(continued)

	ADULTS		LARVAE	
	No. of Specimens	No. of Collections	No. of Specimens	No. of Collections
SUBFAMILY CULICINAE				
Theobaldia impatiens**	2	2	0	0
T.inornata	6	3	0	0
T.melanura	70	52	1971	265
T.morsitans	7	6	51	17
Total Theobaldia	85	63	2022	282
Uranotaenia sapphirina	19	12	2318	693
Wyeomyia smithii	9	1	16	2
Total CULICINAE	23,484	7,933	249,603	39,261
SUBFAMILY CHAOBORINAE***				
Chaoborus	41	16	37	20
C.albatus				
Chaoborus albipes	0	0	5	2
C.americanus				
C.punctipennis				
C.trivittatus				
Total Chaoborus	41	16	42	22
Corethrella brakeleyi***	0	0	14	5
Dixa	11	6	195	84
D.centralis				
D.clavata				
D.cornuta				
D.modesta				
D.notata				
Total Dixa	11	6	195	84
Eucorethra underwoodi**	0	0	3	3
Mochlonyx	0	0	24	11
M.cinctipes				
M.fuliginosus				
M.karnerensis				
Total Mochlonyx	0	0	24	11
Total CHAOBORINAE	52	22	278	125
GRAND TOTAL	23,536	7,955	249,881	39,386

* Not collected by Survey
** Recorded by Survey for the first time in Massachusetts
*** Species not routinely identified by Survey